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July 4th, 2007

Dear Señor Bolaños and Señora Solanos:

What follows is our report entitled *Better Waste Management Practices for ESPH*. It was written for the Empersa de Servicios Publicos de Heredia, S.A. between May 11th and July 4th 2007. Preliminary research was completed on the Worcester Polytechnic Institute campus in Worcester, Massachusetts in the United States. Our professors, Professor Lorraine Higgins and Professor Tahar El-Korchi, will simultaneously receive a copy of this report for evaluation. Upon faculty review, the original report will be electronically catalogued in the Gordon Library of the Worcester Polytechnic Institute. We would like to thank you for the time you have dedicated to us.

Sincerely,

Anthony Morocco

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Benjamin St. James

Report Submitted to:

Professor Lorraine Higgins and Professor Tahar El Korchi

San José, Costa Rica

By:

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In Cooperation With

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La Empresa de Servicios Publicos de Heredia, S.A., Heredia, Costa Rica

Better Waste Management Practices for ESPH

7/4/07

This project report is submitted in partial fulfillment of the degree requirements of Worcester Polytechnic Institute. The views and opinions expressed herein are those of the authors and do not necessarily reflect the positions or opinions of La Empresa de Servicios Publicos de Heredia S.A. or Worcester Polytechnic Institute.

This report is the product of an educational program, and is intended to serve as partial documentation for the evaluation of academic achievement. The report should not be construed as a working document by the reader.

Abstract

Empresa de Servicios Públicos de Heredia (ESPH) is a utilities company located in Heredia, Costa Rica that supplies potable water, electricity, and public lighting to the citizens of Heredia. As a byproduct of the services ESPH provides, hazardous wastes stored in ESPH's three warehouse facilities have built up to the point where they adversely effect the environment.. Once onsite in Costa Rica, we selected two of these hazardous wastes, Polychlorinated Biphenyl containing electrical transformers and mercury-containing HID lamps. Our goal in this project was to offer solutions for better handling and storage for these wastes as well as to compile feasible options for disposal.

Authorship Page

The content in this report was contributed equally by all members of the group.

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We would like to thank Señor Bolaños, Señora Solano, and the staff at La Empresa de Servicios Publicos de Heredia for being such understanding, cooperative, and friendly liaisons to work with. We would also like to thank Doctor Sergio Musmanni of CMPML, Professor Arrieta of CICA, Señora Aguirre of ICE, Mr. Boyne Drummond and Mr. Carlos Alban of TREDI, and Mrs. Bea Ruscillo of FTA Logistics for their timely help for this project. We would like to thank WPI for giving us the opportunity to come to this stunning country and to work on a project of this caliber.

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Executive Summary

La Empresa de Servicios Publicos de Heredia (ESPH) provides electricity, water, and public lighting to some 50,230 users in the province of Heredia. However, as a byproduct of providing such utilities, ESPH has accumulated hazardous wastes that threaten Costa Rica's fragile ecosystem. ESPH stores some of the wastes, such as polychlorinated biphenyl (PCB)-containing transformers and mercury-containing high intensity discharge (HID) lamps, in warehouses as a means of isolating them from the environment. However, not only do these wastes still pose a serious threat to Costa Rica's ecosystem, they also bar the company from being recognized internationally as being environmentally safe by the ISO (International Standards Organization) 14001:2004 standard.

This project was designed to research and recommend environmentally safe options for disposal of ESPH's PCB-containing transformers and mercury-containing HID lamps. Background information was gathered from a variety of sources before working on site, which included a previous IQP with ESPH, the US EPA guidelines on the wastes identified by the sponsor, and the documented ISO 14001:2004 standard itself. Upon arrival in Costa Rica, an interview with Señor Bolaños, environmental engineer and sponsor on behalf of ESPH, narrowed the project to two targeted wastes: HID lamp and PCB transformer hazardous wastes. Additional research on PCBs and HID lamps was then done to elaborate on health effects and disposal practices for each.

To address these waste management problems, we investigated four research topics. Those topics were:

- What is the amount and condition of each waste?
- What are the current legal implications for waste management of PCB-containing transformers and HID lamps?
- What changes can be made to handling and containment procedures?
- What waste management resources and procedures are available for disposing or recycling PCBs and mercury-containing lamps in Costa Rica and what is the associated cost and feasibility of each option?

To identify the amount and condition of each waste, estimates were obtained from warehouse managers and photographs were taken of both spent transformers and for HID lamps. ESPH currently stores an estimated 300 transformers; 8 have been tested and 4 were found to contain dangerous levels of PCBs. ESPH also stores an estimated 30,000 HID lamps in three sealed cardboard boxes stacked on top of each other that were roughly 1.5 meters deep, wide, and long. The haphazard containment of both the PCB-containing transformers and the broken state of the lamps poses health risks to workers and violates several article subsets of the *Codigo Ambiental Internacional*, (2001).

In order to comply with the laws in the *Codigo Ambiental Internacional*, (2001), the handling and storage procedures ESPH employ will have to be changed. Effective handling and storage procedures were found in online research from the EPA, the Basel Convention, Costa Rican law, and in phone interviews with companies that provide disposal services. To better handle and store PCB-containing transformers, proper equipment, including goggles, gloves, aprons, and charcoal HEPA filter-equipped masks

should be worn while testing and handling PCB oils. Proper testing of the transformers is best done by Clor-n-oil 50 testing kits. The transformers should be sealed and marked to indicate the results of the tests immediately after testing, and no PCB oil should be left exposed to open air while in storage. To better handle and store HID lamps, ESPH employees should take care not to allow the lamps to break. When storing the spent, unbroken lamps, they should be placed in the original packaging they came in and stored until they can be properly disposed of.

Interviews with experts at CICA, CNP+L, and ICE determined that there are no recycling facilities available in Costa Rica for mercury-containing HID lamps, and that there are no incineration facilities in Costa Rica for PCBs. However, interviews with these experts and internet research that followed helped us identify twelve companies that may take ESPH's PCB-containing transformer and/or mercury-containing HID lamp wastes. Upon further analysis, all but three of those companies were determined to be unfeasible for managing ESPH's wastes due to their inability to give cost estimates, inability to handle the specific conditions or types of wastes ESPH had, or due to international and national laws pertaining to the transport and disposal of these wastes.

The four feasible companies were FTA Logistics, TREDI, Bethlehem Apparatus Co., Inc and Veolia Environmental. FTA Logistics' services include the shipping and handling of both varieties of wastes, legal paperwork, and incineration/mercury recycling to be done at facilities in Finland. The prices for FTA Logistics' services are $4.70 US - $5.37 US/kg for PCBs and $10.74 US - $12.08 US/kg for HID lamps. TREDI supplies the exact same services via incineration and recycling facilities in France, at $4.50 US/kg for PCBs and at $19.84 US/kg for HID lamps. Bethlehem Apparatus Co., Inc. offers only

recycling services for HID lamps at a cost of $6.03 US/kg, but the shipping and legal paperwork would have to be managed by ESPH. Veolia Environmental offers only incineration services for PCB transformers at a cost of $3.50 US - $4.00 US/kg for the same services provided as TREDI and FTA Logistics.

Final recommendations to ESPH are to use FTA Logistics for recycling of the mercury in HID lamps and Veolia Environmental for the incineration of ESPH's PCB oils. This recommendation was made based on the convenience of using one company's service and the fact that FTA Logistics' cost for removing HID lamps is significantly better than TREDI's. Similarly, Veolia was chosen for PCB oils since they offer the most competitive rate for their services.

For future investigation, we recommend that ESPH attempt to make contact with Indaver; though we were able to make initial contact with company representatives, we did not receive secondary response in email or by phone. If there presents enough of a market by pooling PCB wastes with other, larger companies, it could be feasible that Holcim Geocycle could become a domestic option for disposal of PCB wastes. In our interview with Señora Aguierre, we were informed that ICE is in the process of building a local incineration plant for the disposal of transformers with low levels of PCBs. This plant should be completed by the end of the year, meaning that disposal of spent transformers could be an alternative to storing them in ESPH's warehouses.

Resumen Ejecutivo

La Empresa de Servicios Públicos de Heredia (ESPH) proporciona electricidad, el agua, y la iluminación pública a unos 50.230 usuarios en la provincia de Heredia. Como subproducto de proporcionar tales utilidades, ESPH ha acumulado los desechos peligrosos que amenazan el ecosistema frágil de Costa Rica. ESPH almacena algunas de los desechos, tales como Bifenilos Policlorados (PBC) - conteniendo los transformadores y mercurio-conteniendo las lámparas de intensidad alta de la descarga (HID), en almacenes como los medios de aislarlos del ambiente.. No sólo estas desechos todavía plantean una amenaza seria al ecosistema de Costa Rica, ellas también barran a compañía del reconocimiento internacionalmente como siendo ambientalmente seguras por el estándar de la ISO (organización de estándares internacional) 14001:2004..

Este proyecto fue diseñado para investigar y para recomendar ambientalmente las opciones seguras para la disposición de los transformadores PBC y las lámparas-mercurio de ESPH. Información fue recopilada de una variedad de fuentes antes de trabajar en el sitio, que incluyó un IQP anterior con ESPH, las pautas de los EE.UU. EPA en los desechos identificadas por la empresa, y documentó el estándar sí mismo de la ISO 14001:2004. Sobre llegada en Costa Rica, una entrevista con Señor Bolaños, el ingeniero ambiental y el patrocinador a nombre de ESPH, enangostaron el proyecto a dos desechos apuntadas: Lámpara HID y desechos peligrosos del transformador del PBC. La investigación adicional sobre PBCs y las lámparas HID entonces fue hecha para elaborar en efectos de salud y prácticas de la disposición para cada uno.

Para tratar estos problemas de la gestión de desechos, investigamos cuatro asuntos de la investigación. Esos asuntos eran:

- ¿Cuál es la cantidad y la condición de cada desecho?
- ¿Cuáles son las implicaciones legales para la gestión de desechos transformadores PBC y de lámparas HID?
- ¿Qué cambios se pueden realizar a los procedimientos de la dirección y de la contención?
- ¿Qué recursos y procedimientos de la gerencia de restos están disponibles arreglar o para reciclar PBCs y las lámparas HID en Costa Rica y cuáles son el coste asociado y la viabilidad de cada opción?

Para identificar la cantidad y la condición de cada desecho, las estimaciones fueron obtenidas de encargados del almacén y las fotografías fueron tomadas de ambos transformadores gastados y para las lámparas HIDESPH almacena actualmente los 300 transformadores estimados; se han probado 8 y 4 fueron encontrados para contener niveles peligrosos de PBCs. ESPH también almacena las 30.000 lámparas HID estimadas en tres cajas de cartón selladas apiladas encima de uno a que tenían áspero 1.5 metros profundos, anchos, y de largo. La contención casual de los transformadores PBC y del estado quebrado de las lámparas plantea riesgos de salud a los trabajadores y viola varios subconjuntos del artículo de *Codigo Ambiental Internacional,* (2001).

Para conformarse con los leyes en el Codigo Ambiental Internacional, (2001), la dirección y los procedimientos del almacenaje que ESPH emplean tendrá que ser cambiada. Los procedimientos eficaces de la dirección y del almacenaje fueron

encontrados en la investigación en línea del EPA, la convención de Basilea, ley de Costa Rica, y en entrevistas del teléfono con las compañías que proporcionan servicios de la disposición. Para mejorar la manija y para almacenar los transformadores PBC, el equipo apropiado, incluyendo los anteojos, los guantes, los delantales, y las máscaras filtro-equipadas HEPA del carbón de leña debe ser usado mientras que prueba y maneja los aceites del PBC. La prueba apropiada de los transformadores es la mejor hecha por el Clor-n-oil 50 kits de prueba. Los transformadores se deben sellar y marcar para indicar los resultados de las pruebas inmediatamente después de la prueba, y ningún aceite del PBC no se debe dejar expuesto a al aire libre mientras que en almacenaje. Mejorar la manija y almacenarla las lámparas HID, empleados de ESPH deben tomar cuidado para no permitir que las lámparas se rompan. Al almacenar las lámparas gastadas, intactas, deben ser colocadas en la original empaquetando que vinieron adentro y que almacenaron hasta que pueden ser dispuestas correctamente.

Las entrevistas con los expertos en CICA, CNP+L, y el HIELO se determinaron que no hay instalaciones de reciclaje disponibles en Costa Rica para las lámparas HID, y que no hay instalaciones de la incineración en Costa Rica para PBCs. Las entrevistas con estos expertos y el Internet investigan que seguido ayudado nos identificar a doce compañías que pueden tomar los transformadores PBC de ESPH y/o desechos de las lámparas HID. Sobre análisis adicional, todos sino tres de esas compañías fueron determinados para ser irrealizables para manejar los desechos de ESPH debido a su inhabilidad de dar valoraciones de costes, la inhabilidad de manejar las condiciones del específico o los tipos de los desechos ESPH tenía, o debido a los leyes internacionales y nacionales referente al transporte y a la disposición de éstos los desechos.

Las cuatro compañías factibles eran FTA Logistics, TREDI, Bethlehem Apparatus Co., Inc y Veolia Environmental. Servicios de las FTA Logistics incluyen el envío y la dirección de ambas variedades de basuras, de papeleo legal, y de mercurio que recicla para ser hecho en las instalaciones en Finlandia. Los precios para servicios de FTA Logistics son los $4.70 E.E.U.U. - $5.37 US/kg para PBCs y los $10.74 E.E.U.U. - $12.08 US/kg para las lámparas HID. TREDI provee el exacto los mismos servicios vía la incineración y las instalaciones del reciclaje en Francia, en $4.50 US/kg para PBCs y en $19.84 US/kg para las lámparas HID. Bethlehem Apparatus Co., Inc. ofrece solamente el reciclaje de los servicios para las lámparas HID en un coste de $6.03 US/kg, pero el envío y el papeleo legal tendrían que ser dirigidos por ESPH. Servicios ambientales de la incineración de las ofertas de Veolia solamente para los transformadores de PBC en un coste de los $3.50 E.E.U.U. - $4.00 US/kg para los mismos servicios proporcionados que TREDI y FTA Logistics.

Las recomendaciones finales a ESPH son utilizar FTA Logistics para reciclar del mercurio en lámparas HID y de Veolia Environmental para la incineración de los aceites PBC de ESPH. Esta recomendación fue hecha basado en la conveniencia de usar un el hecho de la compañía servicio y de que coste de FTA Logistics para quitar las lámparas HID es perceptiblemente mejor que TREDI. Semejantemente, Veolia fue elegido para los aceites del PBC puesto que ofrecen la tarifa más competitiva para sus servicios.

Para la investigación futura, recomendamos que tentativa de ESPH de hacer el contacto con Indaver; aunque podíamos hacer el contacto inicial con los representantes de la compañía, no recibimos respuesta secundaria en el email o por el teléfono. Si presenta bastante de un mercado reuniendo desechos del PBC con otra, compañías más grandes,

podría ser factible que Holcim Geocycle se podría venir una opción doméstica para la disposición de los desechos del PBC. En nuestra entrevista con Señora Aguierre, éramos informados que el HIELO está en curso de construcción de una planta local de la incineración para la disposición de transformadores con los niveles bajos de PBCs. Esta planta es debido al final antes del extremo del año, significando que la disposición que transformaba gastada podría ser un alternativa para almacenarlos en los almacenes de ESPH.

1. Introduction

Access to electricity and drinkable water for all residents is a goal that many developing countries seek to achieve. In the province of Heredia, Costa Rica, Empresa de Servicios Públicos de Heredia (ESPH) provides electricity, water, and public lighting to the area's residents. However, as a byproduct of providing such utilities to Heredia, ESPH has accumulated solid wastes that threaten Costa Rica's ecosystem. To best provide its services, the wastes the company produces need to be dealt with in a way that is safe for the environment.

Some of the solid wastes ESPH has accumulated are stored in three warehouses, aptly named warehouse A, warehouse B, and "The Patio," as a means of isolating the contained wastes from the environment. These wastes include (but are not limited to) PCB's, mercury-containing lamps, used print cartridges, PVC piping, and various metals. Other wastes such as contaminated sediment from their waste water operations and wood from their farmland and conservation land cannot be stored in ESPH's storage facilities. All of these wastes are detrimental to the environment, and they bar the company from being recognized internationally as being environmentally safe by the ISO (International Standards Organization) 14001:2004 standard as well. This recognition is only accredited to companies that achieve the high level of environmental safety outlined by the ISO 14001:2004 standard.

The purpose of this project was to first identify the quantity of existing wastes, to outline the hazard that the wastes pose to the environment, and to determine best

practices of resale, recycling, and removal. Once this information was found, two wastes were chosen to be the focus of this project on site; specifically, we developed recommendations for management of polychlorinated biphenyls and HID lamps. Our project team conducted onsite investigations of these wastes. We held a series of interviews with environmental protection agencies and waste management experts to make clear what sources are available in Costa Rica, compiling a list of available resources for managing waste, identifying legal constraints, and based on the applicability of each option, determining which were most feasible to create recommendations that best suited the needs of ESPH.

2. Background

In this chapter we provide an overview of ESPH, explain how the company's waste is generated, define the ISO 14001:2004 standards and how to comply with them, and outline general procedures for waste recycling and disposal. Information from this section was used to conduct our analysis of procedures for reducing ESPH's specific solid wastes in a way that was both cost effective and environmentally safe enough to comply with ISO 14001:2004 standards.

2.1 Introducing ESPH

The history of ESPH shows that it has been environmentally conscious since its beginnings. In 1915, electrical services were made available to the people of the Heredia province through a company called the Joint Administration of Municipal Electrical Service of Heredia (JASEMH) (Stephanie LeGare et al. 2005). This power was supplied by the La Joya hydroelectric power plant, which still operates northeast of Heredia's boundaries. To meet a growing need for electricity, a second hydroelectric power plant was built, called the Carrillos hydroelectric plant, which still operates along the Río Poás northwest of Ángeles (Stephanie LeGare et al. 2005).

In 1998, JASEMH separated from government control to form the privately governed ESPH we know today. This company is responsible for providing Heredia's drinking water, public street lighting, and electrical energy needs (Stephanie LeGare et al.

2005.) According to a former IQP project group working with ESPH (Paul Armano et al., 2004) the company identifies itself as being “an innovative company with social and environmental responsibilities to offer excellent service, supported by the people and seeking the satisfaction of clients and the community at large” (p 10.). ESPH’s vision is “To be a leader in public services who improves the quality of life of the community, in harmony with the atmosphere” (ibid.)

As it is such a large company supplying an estimated population of 50,230 users (Juan Diego Bolaños, personal communication, 2007) there are large amounts of waste generated by the various services provided by ESPH. The processes that generate these wastes include (but are not limited to) hydroelectric plant operation, aqueduct and street lighting installment and maintenance, water treatment plant maintenance, and normal office function. ESPH is seeking to remove solid wastes that they had accumulated in order to comply with ISO 14001:2004 standards, which will certify that the company is environmentally friendly on an international scale.

2.2 Wastes generated by ESPH

The wide range of services the company provides has caused the accumulation of a plethora of solid wastes. Table 1 lists these wastes in order from most to least hazardous. This impact scale is governed by a formula (impact = frequency x (severity + scope + control)) in the ISO 14001:2004 standard, which is further explained in section 2.3 of the background. The scale ranges from 3 [1*(1+1+1)=best] to 48 [4*(4+4+4)=worst].

Table 1: List of wastes and level of environmental impact presented for each waste

Name of waste	Level of environmental impact
Sediment	40
Polychlorinated biphenyls (PCBs)	36
Mercury-containing lamps (fluorescents/HIDs)	32
Pressure treated wood	32
Plastics	32
Porcelain	32
Polyester fabric	32
Steel	32
Iron	32
Copper	28
Aluminum	28
Bronze	28
Printer cartridges	28
PVC (Polyvinyl Chloride)	28
Glass	24
Tree branches	24

ESPH had effectively isolated some of these wastes from the environment by storing them in warehouses. According to John R. Holmes in, *Managing Solid Wastes in Developing Countries* (1984), such storage measures are necessary to keep them from impacting the environment until they can be safely removed. These wastes and general removal methods for them are explained in detail in section 2.4 of the background.

2.3 ISO 14001:2004

By improving management of solid wastes mentioned in Table 1, ESPH will be one step closer to becoming certified in accordance to ISO 14001:2004 standards. The ISO (International Standards Organization) sets worldwide standards for industrial machining, manufacturing, industrial molding, forming, food standards, and in ESPH's case, environmental standards (*What Is ISO?* 2007, ¶ 3). As a result of being certified in

accordance with ISO 14001:2004 standards, ESPH will become nationally accredited and will be able to conduct its operations more effectively from an environmental standpoint.

At the core of the ISO 14001 standard is the conception of an EMS, or Environmental Management System. There are six sections of an EMS:

- Company's environmental policy
- Planning
- Implementation and operation
- Checking and corrective action
- Management review
- Continual improvement

NSF International (2005, pages 13-14)

The environmental policy section requires a company to develop a policy that commits to addressing all environmental impacts of its processes. ESPH has already done this according to its mission statement:

> *The environmental compromise is part of the mission and vision of this business. It established and maintains a public compromise with safe materials… It has identified the environmental aspects and impacts associated with its processes. (Valoración De Impactos Ambientales,* 2007)

The planning section requires a company to identify its activities and those activities' impacts on the environment, to determine which of those impacts are most influential, and to document any information on the above topics. From this, a company can set goals to eliminate or reduce the impacts of these activities, and create programs to achieve the goals mentioned. The implementation and operation section requires a company to create a management position specifically for overlooking the implementation of the EMS. The checking and corrective action section requires a company to monitor and measure operations that have significant environmental impacts. The management review section requires the manager of the EMS to periodically review all of the stored documents

required by ISO 14001 and/or those related to the EMS. From this, the manager can improve the EMS based on these documents, which brings continual improvement and perpetuates the cycle. Figure 1 shows a visual of the EMS cycle:

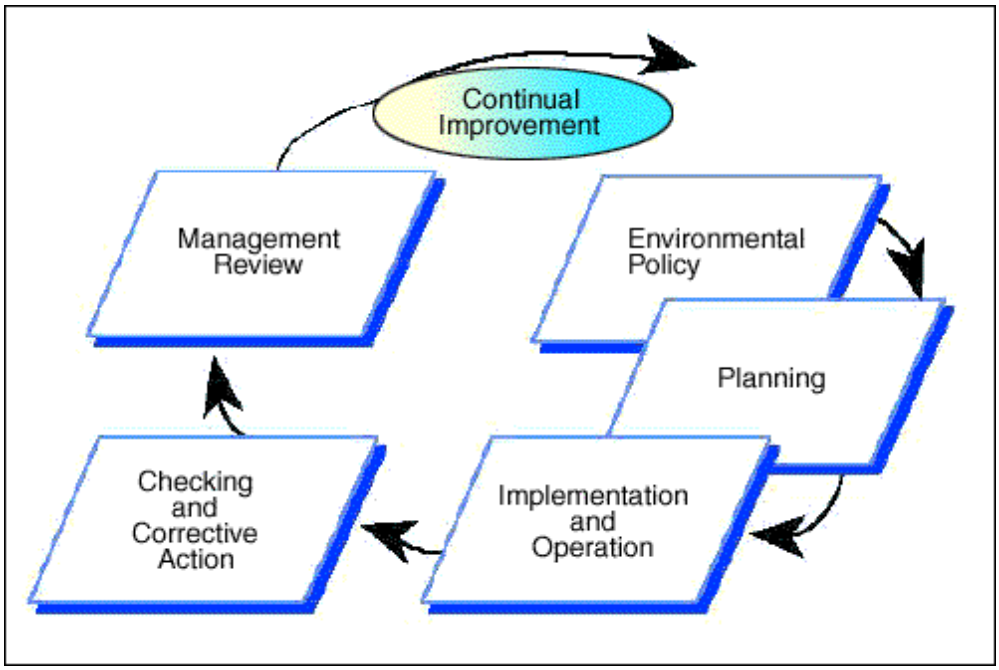

Figure 1: The EMS Cycle (The Industrial Standards Institute, 2006, Chapter 2)

At the start of our project, ESPH was working on the "Planning" section of the EMS, and this project contributed to that planning through our proposed waste removal procedures. As defined by ISO, the planning section requires a company to identify its activities and their environmental impacts, to determine which of these impacts are most significant, to document this information and set targets to eliminate pollution, and to create programs to address these targets.

Señor Juan Diego Bolaños, Environmental Engineer at ESPH, provided a table *(Valoración De Impactos Ambientales,* 2007) that served as a scale for the severity of the impacts of wastes. This scale was based on the desire to meet ISO standards for planning.

It has four different categories: frequency of each waste's impacts on the environment, the severity of their impacts, the scope or area impacted by each waste, and what level of control is being imposed on each waste.

Each waste in each category was rated on a scale from 1 (the least harmful) to 4 (the most harmful.) The impact of each waste was decided by a formula in which "Scope," "Severity," and "Control" categories are added and then their sum is multiplied by "Frequency" (see Table 2.) The number generated by this formula was placed on a waste scale; the green category was safe, the yellow category was mildly hazardous, and the red category it was extremely hazardous.

Table 2: ESPH's Environmental Table Scale (Valoración De Impactos Ambientales, 2007)

Scale	**Frequency (F)**	**Severity (S)**	**Scope (A)**	**Control (C)**
4	The impact is present once a month or more frequently.	Seriously impacts the health of the people, flora and fauna.	Regional. It affects the areas in which the business conducts its activities.	There are no mechanisms of control.
3	The impact is present once every three months.	Impacts are direct and continuous, but not serious to the people, flora and fauna.	Local. It affects the immediate vicinity of the site.	Some methods are currently used, but they are inefficient.
2	The impact is present every six months.	Impacts are indirect to people, flora and fauna.	Internal. It affects and is maintained in the facility.	It is monitored and impact is mitigated.
1	The impact is present once a year or less frequently.	The impacts don't cause significant damage.	Proximal. It affects a point of no more than 25 square meters.	It is monitored and impact is prevented.

To obtain the significance (the scale of each waste's impact),multiply the value of the frequency by the sum of the severity, scope, and control.

ESPH has identified the impact of almost all of its produced wastes using the impact formula as dictated by the ISO 14001's "planning" section. However, they had

not created programs to meet their goal of safely removing those wastes to become more environmentally compliant. Our task was to provide ESPH with recommendations to create effective programs to meet the goal of removing one or two wastes selected from the complete list.

Once feasible waste removal programs of are implemented, ESPH will be one step closer to becoming certified in ISO 14001:2004 standards, and as a result of such certification, will become an internationally accredited company.

2.4 Waste details and best removal procedures

Between Costa Rica's conservational efforts toward preserving the rainforest and the fact that the country itself is small, there is little room for landfills and waste buildup is a difficult problem to address. As a result of that lack of space, the prices for disposal are high, and landfills are an expensive option. Many cities do not have their own waste storage plants, so they must pay to ship wastes to the nearest available landfill (R. Arrieta, personal communication, May 25, 2007.) Thus, resale and recycling are the best options when possible and the best known procedures for resale, recycling, and disposal is an important topic to address.

In section 2.4.1, each waste is described in detail, in the same order as shown in Table 1 in section 2.2. These details include the dangers posed and best methods of dealing with each waste type, and details on the two wastes that were targeted in this project were provided in greater detail. While documentation was found on recycling and disposing of wastes in third world countries, the most elaborated documented guidelines for disposing of these wastes are given in accordance with standards in the U.S. The

methods described below were developed in the U.S., but must be adapted to the context of Costa Rica.

2.4.1 Waste specific environmental threats and best removal procedures

Sediment, according to the EPA, is waste that settles to the bottom of lakes, rivers, and other bodies of water. It is produced by dumping waste or waste water into bodies of water and is not a proper means of disposal unless it is done so in designated zones in the ocean, which are miles from shore. Contaminated sediment is often highly detrimental to marine life, as chemicals from the sediment can seep into the water and poison animals. (EPA, 2006, ¶ 1)

To properly manage areas that are contaminated by sediment, several solutions are given by the EPA. The first option is obviously removal, which is difficult, and must be done in a way that does not cause additional harm to the environment in the process. In most situations, it is impractical to remove the sediment, since removing the top layer of sediment can release more toxic chemicals into the environment. The EPA says that if you want to leave the sediment where it is, you can either wait for natural sand and silt to cap the sediment, which would create a naturally contained deposit in the earth, or you can artificially cap the sediment with clean sand, clay, gravel, or other material. Long term monitoring is necessary in the case of capping to make sure that toxic substances do not escape through the cap covering the sediment. (EPA, 2006, ¶ 1, 2, 3, 7)

PCB's, (polychlorinated biphenyls) according to the EPA, are found in electrical equipment, like ballasts and transformers, for their favorable electrical insulating capability. They are synthetic chlorinated hydrocarbon compounds that consist of two

benzene rings linked by a single carbon–carbon bond, with from 1 to all 10 of the hydrogen atoms replaced with chlorines. PCBs have been produced commercially since 1929 (WHO, 2003, chap. 4, ¶ 5). The appearance of PCBs ranges from oily liquids to waxy solids. Due to associated chemical non-flammability, chemical sustainability, high boiling point and electrical insulating properties, PCBs were used in numerous industrial and chemical applications (WHO, 2003, chap 2, ¶ 6). Because PCBs resist both acids and alkalis and are relatively heat-stable, they have been used in dielectric fluids in transformers and capacitors. Exposure to PCB can be either through ingestion of contaminated water/food or by inhalation through air. PCBs have been found to bioaccumulate in food chains where they pool in liver and adipose (fat) tissue. In the case of transformer oil, leaks of contaminated oil can enter the water table. Aquatic ecosystems have been shown to be severely effected by PCBs through the metabolism of PCBs through contaminated sediment ingested by shellfish PCBs in humans can be passed from mother to child through the placenta as well as through the mothers' milk. (WHO, 2003, chap. 2, ¶ 5)

When numerous health effects were discovered in the 60's and 70's, the manufacture and use of PCBs was phased out. Prior to the banning of use in 1977 of PCBs 1.5 billion pounds were manufactured in the United States alone (EPA, 2007). The piece of legislation that initiated the cessation of production of PCBs was Section 6(e) of the Toxic Substances Control Act (TSCA) passed in 1976; through this act manufacture, production and distribution of PCBs (EPA, 2007). According to Señor Bolaños, PCBs are a regulated technology in Costa Rica because of the known health effects (Juan Diego, Personal Communication, 2007).

Health effects to humans from exposure to PCBs come in both cancerous and non-cancerous effects. PCBs have been shown to cause major damages to the immune system, reproductive system, nervous system, and endocrine (hormone) system

PCBs have been shown to cause many types of cancers in humans including breast, brain, melanoma, and lymphoma. Cancers specific to PCB exposure in workers are rare liver cancers and malignant melanoma. This may be due to the fact that PCBs are man-made compounds, so they tend to bioaccumulate in animals such as fish and other animals by binding to sediment (WHO, 2003, chap 9.1, ¶ 1).

Non-cancerous side effects of PCB exposure include:

- Parkinson's Disease
- Diabetes
- Hyperthyroidism
- Hypothyroidism
- fracture of the epiphysis (head) in long bones such as the femur
- birth defects (including smaller head circumference, Espina Bifida and fetal respiratory problems)
- Lowered IQ Scores
- damage to the liver and pancreas
- endometriosis
- lupus
- chronic anemia
- irritation of mucosa
- various skin diseases

(Juan Diego, Personal Communication, 2007)

The World Health Organization performed tests on rats that show one-time exposure to PCBs via an oral dose of 1315mg Aroclors 1242, 1254, and 1260 /kg body weight included observed effects of diarrhea, respiratory depression, dehydration, decreased response to pain stimuli, unusual gait and stance, oliguria (decreased production of urine), and coma. In autopsied rats, researchers observed anatomical changes in kidneys and liver, hemorrhage in the lungs, stomach, pancreas, and

inflammatory response in the duodenum (an area of the large intestine) and glandular part of the stomach. (WHO, 2003, chap 8.3, ¶ 2)

Immunoefficiency tests pertaining to PCBs effect on humans were tested on Rhesus monkeys due to their genetic similarity to humans. Exposure was shown to significantly decrease the size of the thymus gland in infant monkeys. Though the thymus gland naturally reduces in size throughout life, in early stages of development it is critical in creating antibodies to protect the body against foreign agents. Tests included the introduction of sheep red blood cells into the infant monkey's bloodstream, which showed a slowed response as well as a lowered resistance to Epstein-Barr virus and other infections agents. Because the immune system is weakened, individuals are more susceptible to pneumonia and viral infections (WHO, 2003, chap 8.6, ¶ 2).

Testing of PCB exposure leads to results showing that PCB exposure can be linked to reduced birth weight, smaller head circumference, and shorter gestational age. In a case study (Jacobson et al., 1985), a sample size of 242-infant mother pairs (71 infant–mother controls) were monitored for PCB exposure through ingestion of contaminated fish (>11.8kg over 6 years). It was observed that prenatal exposure lead to general neuromuscular immaturity. Children exposed to PCBs were monitored 1-16 weeks postpartum, with follow-ups at 4 and 11. According to the study, at the age 11, the most highly exposed children were 3 times as likely to have low average IQ scores ($P < 0.001$) and twice as likely to be at least 2 years behind in reading comprehension ($P = 0.03$) (Jacobson & Jacobson, 1996) (WHO, chap 9.3.2,¶ 2)

According to the EPA's Toxicological Profile for Polychlorinated Biphenyls (PCBs), methods for disposal of PCBs include encapsulation, incineration, irradiation,

and microbial/chemical remediation. Encapsulation is the most basic form of safe disposal, and is done by filling a 55 gallon drum with the PCB containing materials and properly sealing that drum. In incineration, PCBs are first mixed in the presence of fuel and oxygen then are burned at a temperature exceeding 1200° centigrade for at least 2 seconds. Lack of oxygen in a system of incineration disposal may lead to the incomplete decomposition of biphenyls (EPA, p 497, ¶ 1). In irradiation, gamma rays are applied to substances already in mineral oil or isopropanol mixtures. PCBs become dechlorinated and are broken down to chloride and biphenyl (EPA, p 498, ¶ 3). In Microbial remediation, specific bacteria are applied to contaminated sites to metabolize and decompose the PCBs. In this process however, bacteria are selective to what types of biphenyls they will break down and the process is slow going compared to other methods of disposal. Because microbes can often find better sources for carbon sources than PCBs in real world environments, efficacy of application of this approach is questionable (EPA, p 498, ¶ 2). In chemical remediation, specific chemical compounds are used to break down PCBs by cleaving Chlorine ions from the PCB's structure (EPA, p 498, ¶ 3).

In Figure 2, a photograph is shown of one of the streetlight transformers that were in ESPH's warehouse.

Figure 2: Image showing a transformer containing PCBs in ESPH's warehouse

Fluorescent lamps and HID (high intensity discharge) lamps, according to the EPA, are widely used in business as they are a low-cost, high efficiency source of lighting. Fluorescent lamps consist of a sealed glass tube that contains low pressure argon gas and mercury gas. (EPA, 1994, p. 2-3) HID lamps are similar to fluorescent lamps, but they produce a higher quantity of light per unit area of lamp package. The gases in these lamps, which are released upon breaking the bulbs, are harmful to the atmosphere and to human health. According to Thomas W. Clarkson, mercury gas that escapes into the atmosphere returns to the earth during rainfall, and is absorbed by organisms that ultimately pass the mercury on to our food supply. Ingestion of mercury causes many

health defects, which can include brain damage (which specifically effects vision and hearing.) Mercury ingestion is especially detrimental during pregnancy, as humans are most vulnerable to mercury during prenatal stages of development. Prenatally poisoned infants exhibit a range of effects that can range from cerebral palsy to subtle developmental delays. (1993.)

In the US in 1994, according to the EPA, approximately 82% of mercury-containing lamps were placed in landfills, 16% were incinerated, and only 2% were recycled. The EPA also states that it is most efficient for companies to replace all of the depleted mercury-containing lamps in the target area at the same time, and that the company replacing them is to remove the used bulbs safely in a way that keeps breakage of these bulbs minimal. By putting the bulbs into safe containers, the contractor can transport the bulbs to a landfill or recycling facility while minimizing breakage. If the hazardous waste landfill option is employed as the final destination for the bulbs, the bulbs remain inside the safe containers in the landfill and the gases are effectively contained. If the recycling option is employed as the final destination for the bulbs, the recycling procedure extracts the hazardous gases from the bulbs and they are reused in other manufacturing applications. (EPA, 1994, p. 3) Because it is uncertain that Costa Rica has the hazardous waste landfills or recycling facilities necessary for proper mercury-containing lamp disposal, it may be necessary for ESPH to resort to international solutions for recycling or land filling. Below in Figure 3 is displayed a photograph of expired, yet unbroken lights from ESPH's warehouse.

Figure 3: Image showing expired, mercury-containing lamps from ESPH's warehouse

Pressure treated wood, according to the EPA, is treated with CCA (chromated copper arsenate) pesticides to preserve the wood. This preservative contains chromium, copper, and arsenic. It is not suggested for use in residential areas because CCA is highly carcinogenic and can be dislodged from the wood by physical contact. Also, arsenic leeches from the wood into surrounding soil over time. CCA treated wood should not be burned or used as compost or mulch, as this will release the carcinogenic chemicals into the surrounding environment. If this waste type is targeted, CICA will likely be able to provide us with information on the threat posed by pressure treated wood in Costa Rica, since the treatment of the wood may be different outside the US. Until its hazard can be assessed by such means, it is safest to dispose of it by sending it to a hazardous waste

landfill if it cannot be reused in an environment where it will have minimal human and animal contact (EPA, 2006, ¶ 1, 2)

Plastics, according to the EPA, used for bottles and containers, are usually recyclable through processes that vary depending on their resin code. These can be sent to recycling facilities where they undergo a long recycling process, which eventually has the plastics melted down into small beads of plastic, which are then sent to manufacturers. The resin codes on some plastic containers can be read to tell whether or not they can be recycled. Some plastics are difficult to recycle, but those with resin codes "1" and "2" are most easily recycled. (EPA, 2006, ¶ 7, 9, 13, 14)

According to J. R. Holmes (1984,) in third world countries (in the case being described, India,) a system of plastic recycling can be found. In this system, collectors based in the areas surrounding dumps employ scavengers to retrieve recyclable plastics from the area (streets, refuse dumps, etc.) The collectors also employ a small workforce to separate the grades of plastic according to the quality of the plastic, and then each grade of plastic is sold to granulators by the employing collectors. The granulator treats each grade of plastic according to its quality to recycle it into a raw form that can be reused for making lower grade plastic materials. These materials are then sold as a cheaper alternative to virgin plastic to companies that can appeal to lower class consumers by making lower quality plastic products and selling them for low prices. If this system is employed in Costa Rica, and ESPH can find a good merchant in the area who will take its plastics, the company can actually make a profit from this waste.

Porcelain, according to the EPA, used as brushings and insulators can be crushed and reused. Because this waste is useful in abrasives, snow melts, tiles, and sculptures,

there is actually a small profit margin if an effective cooperative system with an outside vendor can be established. This form of recycling significantly reduces the waste processing costs of porcelain, and if a strong bond can be made with the recycler, a profit can be discussed for high quantity shipments. Also, the savings that result from reusing (the purest form of recycling) porcelain brush heads and insulators, however, are better than any profit or cost that can be associated with recycling or removing used porcelain materials (EPA, 1997, Ch. 3).

Polyester Fabrics, according to the EPA, are used mainly in clothing and one of the best ways to remove them is by donating them to charitable organizations so they can be reused. 61% of such fabrics exported by the US are sent to foreign countries where they maintain a high enough market value to pay for processing costs. Fabrics that cannot be sold or given charitably are sent by these organizations to textile recovery facilities, where the materials can be recycled. If such charitable organizations can be found in Costa Rica, ESPH can improve its name by giving or selling used fabrics to those organizations. (EPA, 2006, ¶ 1, 2, 3, 6)

Since textiles are one of Costa Rica's main exports according to the (CIA, 2007, Industries, ¶ 1) it is highly possible that there are textile recovery facilities in Costa Rica that ESPH's polyester fabrics could be sent to. Fabrics could also be recycled within the company by using them for cleaning up after and absorbing toxic spills, which would also reduce the environmental impact of such occurrences. (It is important to note that once the textiles are used in this way, they need to be disposed of by a contained procedure that will not let the toxic contents of the rags leech into the environment.) Thus, the best option would be either reusing the fabrics for cleaning purposes or selling

them to a textile recovery facility, depending on which is most available and has the best cost benefits (J. R. Holmes 1984). If those options are not available, the fabrics could be sold or given to a second hand clothing distributor, such as a charity (EPA, 2006, ¶ 1).

Metals including **Steel, Iron, Copper, Aluminum, and Bronze,** according to the Global Recycling Network, are all recyclable and valuable materials. Scrap metal yards are willing to pay through the nose for these valuable metals, and huge profits can be made under the table, at prices that vary pound for pound. Copper, aluminum, and bronze are especially valuable metals. The source of each metal type can cause the values to fluctuate, but aluminum is worth roughly $0.33 per pound, bronze is worth roughly $0.92 per pound, copper is worth roughly $2.00 per pound, and mixed scrap iron and steel is worth about $122 per ton. Higher profits can be made when greater quantities of these metals are scrapped. These prices may be different in Costa Rica, but the price proportions of each metal should stay the same. A scrap metal yard should be found immediately so that ESPH can make a profit by selling these metals. (Global Recycling Network, 2007, p. 1)

Printer cartridges are hazardous to the environment because the contents are toxic. The contained inks are oil based, thus contaminating any soil they spill onto, and toner dust is also hazardous. However, since printer cartridges are so expensive, it is a huge money saver to send the cartridges back to the manufacturer to have them refilled or recycled. We strongly encourage that these are refilled instead of thrown out, or at least recycled so that expensive parts of them can be reused. Some companies are even willing to pay for used print cartridges. The producer of a print cartridge is generally willing to pay for shipping to recycle the cartridges they produce or, in bulk shipments, will even

pay a stipend for the transaction. Internet links to the programs for recycling printer cartridges from Lexmark, Canon, and Hewlett Packard can be found in the references section. If ESPH can return their cartridges to the manufacturer, it can make a profit or have its print cartridges removed free of charge. (PrintCountry, 2007, ¶ 1, 3, 5, 6)

PVC, polyvinyl chloride, according to the EPA, is a plastic that is used to make pipes, wire and cable coatings, and packaging materials. It is useful because it is stiff, strong, heat resistant, and weather resistant. However, because vinyl chloride is classified by the EPA as a Group A (human carcinogen) material, it is unsafe to burn PVC, as doing so releases vinyl chloride into the atmosphere. Recycling PVC is expensive, and is not commonly used as a means of disposal even in the US because of it is not cost effective. It is thus best to use volume reduction of the PVC (putting smaller pipes into larger ones), and for it to be sent to a municipal solid waste landfill (EPA, 1995, Ch. 4, 21-23, 29). It is likely that volume reduction and removal to a landfill would be the best available option for ESPH, but checking with CICA for any available PVC recycling facilities would be a good plan of action to start with if this waste is targeted.

Glass, according to the EPA, has served as a universal packaging container for centuries, and is appreciated for not only its aesthetic value, but also as being almost completely recyclable, as about 90% of recycled glass is used to make new containers. To recycle glass, the used glass is crushed and sand, soda ash, and limestone are added to the mixture, which is then heated to 2,600 to 2,800 degrees Fahrenheit. The melted glass is then molded into whatever shape is desired. Glass manufacturers actually have a higher demand for crushed glass (cullet) than they do for the raw materials used to make glass because it is cheaper and easier (EPA, 2006, ¶ 1, 2, 3). In fact, glass manufacturers today

are relying upon a constant stream of crushed glass that comes in daily. In third world countries (J. R. Holmes 1984,) glass is recycled and cullet retains a value, since it is in worldwide demand. If ESPH could find a glass product manufacturer that uses cullet to make its products, ESPH may be able to make a profit on the benefit it would provide to this manufacturer.

Tree branches, according to the EPA, can be mulched or burned for energy. Burning branches and other natural debris in the open purely for the purpose of disposal produces greenhouse gases that are harmful to the atmosphere. Mulching is a great way to profit from cut down branches and reduce volume of organic debris. If ESPH was to impose this method by purchasing equipment to make mulch, the mulch could likely be sold to nearby landscaping companies for a profit, or this waste could even be used on the company's grounds to improve ESPH's aesthetic value (EPA, 2006, ¶ 1, 3).

2.5 Closing Remarks

ESPH has taken affirmative action by researching its current practices and by building a spreadsheet that charts the output of each category of waste. It is also evident from these charts that, according to the "Control" column in Table 3 (which is taken from the charts shown in *Valoracion De Impactos Ambientales*, 2007), ESPH is currently making efforts to control the environmental impacts of the wastes. In this table, the higher the number under "control," the less the waste has been managed by the company; a control rating of "4" indicates that there is no control for the waste.

Table 3: "Control" value for each waste type (Tabla De Aspectos E Impactos De Actividades, 2007)

Type of Waste	Control
Sediment	4
PCB	4
Polyester Fabric	3
Porcelain	3
Pressure Treated Wood	3
Mercury-containing lamps	3
Glass	3
Tree Branches	3
PVC	2
Printer Cartridges	2
Bronze	2
Aluminum	2
Copper	2
Plastics	2

However, since the values listed for the control ratings (Table 2 and Table 3) of each of these wastes do not fall below "2" ("2" means it is monitored and impact is mitigated), and since most values listed are "3" ("3" means some methods of control are currently used, but they are inefficient) or more, the control methods have not been adequate enough to prevent the impact of those environmental impacts. By providing recommendations for removing selected wastes, we hoped to bridge the gap between impact and prevention

This chapter has introduced ESPH, described the ISO standards, provided a list of wastes, generally assessed which of the wastes have the strongest impact on the environment, and described what procedures are best for removing said wastes (in both the United States and in some third world countries.) In this project, we focused on two wastes (PCBs and mercury-containing lamps) as suggested to us by Señor Bolaños of

ESPH. The next chapter explains the methods we used to determine the amount and condition of these particular wastes and to determine which waste management procedures are feasible in Costa Rica and for ESPH. We also describe methods for learning about alternative practices in CR not identified in this background research.

3. Methodology

Based on ESPH's challenges to waste management, we formulated questions whose answers were necessary in completing the project. These research questions were as follows:

- What is the amount and condition of each waste?
- What are the current legal implications for waste management of PCB-containing transformers and HID lamps?
- What changes can be made to handling and containment procedures?
- What waste management resources and procedures are available for disposing of or recycling PCBs and mercury-containing lamps in Costa Rica and what are the associated costs and feasibilities of each?

Our goals were to provide reasonable options for management of expired transformers and HID lamps, to provide background information on legal factors, and to suggest better practices for management and storage of waste. Using these goals as a guideline, we were able to provide legal, feasible, and cost effective recommendations to ESPH for removing its hazardous PCB-containing transformers and mercury-containing HID lamps and for reducing the environmental impact of this waste in the future.

3.1 Location, quantity, and condition of each waste

In order to answer our first research question, we initially quantified the conditions and amounts of PCB-containing transformers and mercury-containing HID lamp waste. We had already received some information on the existing quantities/generation of waste, but denominations presented were too vague to develop a realistic idea of the amount of prescribed wastes. Our first step in clarifying this was to hold an interview with Señor Bolaños to determine the sources of waste generation and the locations of the sites at which the waste quantities had been stored. Upon arrival at the determined locations, waste condition was determined mostly by visual inspection and photographic evidence was taken as necessary. Quantitative assessment of stored wastes was made via consultation with waste management staff at ESPH's warehouses.

3.2 Legal implications

Research came from many different sources to define legal aspects of hazardous waste removal. Upon visiting the library at the University of Costa Rica, we investigated legal cases and laws involving waste management, land filling, and development of landfills. We acquired basic information from our interview with Professor Ronald Arrieta regarding waste removal laws and the stringency/leniency of those laws. Dr. Sergio Musmanni at CNP+L also knew about some legal aspects of waste removal.

From our interviews with CNP+L and ICE (whose interview is described in section 3.4 of the report), we were made aware that if we are to ship the waste to another country, international legislation would have to be taken care of to assure legality of the

exchange. The Basel Convention, which will be explained more thoroughly in our results, was a critical piece of legislation that must be fully understood before taking the steps to ship wastes across international borders.

3.3 What changes can be made to handling and containment procedures?

Because ESPH did not employ proper handling and containment procedures for PCB-containing transformers and for mercury-containing HID lamps, it is important to address the issue by informing ESPH of better procedures for handling and containment until the wastes can be properly disposed of. To do this, we researched the issue by collecting data from a variety of online sources, mainly The EPA and Occupational Safety and Health Association (OSHA) guidelines. We also acquired information on the subject while communicating via phone with the companies we contacted for waste disposal options.

3.4 Current resources for managing waste

We established what resources were currently available for managing, recycling and disposing of wastes in a number of ways. First we interviewed Professor Arrieta, a Professor of Chemistry at the University of Costa Rica in San Pedro and representative of CICA (Center in Investigation in Environmental Contamination) to better determine the availability of resale/recycling/removal resources proximal to Heredia. Also, we

scheduled an interview with Doctor Sergio Musmanni from CNP+L (National Center for Cleaner Production) in order to gain more information for waste disposal. Our final interview was with ICE (Costa Rican Institute of Electricity), with Ana Aguirre, the company's head of oil waste management. By this interview, we hoped to find what a larger company in the same situation as ESPH would do with its PCB wastes.

The interview questions for CICA, CNP+L, and ICE were:

- Which of the following disposal methods are available in Costa Rica (local or international) for PCB management and what are the associated costs: Incineration, irradiation, bioremediation, chemoremediation, and hazardous waste land filling?
- Which of the following disposal methods are available in Costa Rica (local or international) for mercury-containing lamp management and what are the associated costs: Mercury recycling and hazardous waste land filling?
- Are there any methods of management available in Costa Rica (local or international) that we have not yet mentioned (and what are associated costs)?
- Are there any contacts you can suggest to us who may deal with or know someone who deals with the specified wastes?

Through visual observation and photography, quantity and conditions of the waste was determined for use in obtaining service cost estimates. From interviews, we gained valuable contact information which allowed us to contact waste disposal companies

directly, thus creating liaisons that ESPH can follow up on in their final analysis of what method will be best for the company in disposing of hazardous wastes.

Due to budget constraints, the associated costs of each management approach decided which options were best to recommend. In our interview(s) with CICA and CNP+L, we inquired on the cost associations for disposal of the wastes.

From interviews with ESPH, CICA, CNP+L, and ICE, we received contact information for companies that may have been helpful to us. Subsequently, these companies were contacted for information regarding paper work and an estimated cost for disposal of HID lamps and PCB containing transformers.

We considered the feasibility of the potential options for recommendation for ESPH. Once we gathered concrete data through the execution of the methods for answering our previous research question, we analyzed the resources, constraints, and associated costs to determine the best methods and recommend them to ESPH. After this analysis was done, methods of removal were prioritized based on resulting impacts on the environment for each respective method. We lastly described the potential benefits from the implementation of the described programs.

4. Results

This chapter presents results from interviews, visual and photographic quantitative assessment of warehoused wastes, research of management options available to Costa Rica, and legal documentation. All of these results yielded answers to the research questions that needed to be answered to offer quality recommendations to the company.

4.1 Amount and condition of each waste

Upon the completion of our first interview with Señor Bolaños, he specified which waste types to deal with and clarified that all of the mercury-containing lamps and PCB containing transformers were contained together within two warehouses. We then gathered photographic evidence of and assessed the quantities of the company's PCB transformers and mercury-containing lamps in the warehouses.

ESPH owns three warehouses; the first two will be referred to as warehouses A (which is not relevant to the project because it was not storing our wastes) and B, and the third will be referred to as "The Patio." At the warehouses, all of ESPH's expired transformers, a few of their new transformers, and their expired HID lamps were contained. Warehouse A did not contain any of our waste. Warehouse B contained one definite PCB transformer, as well as a couple transformers with the possibility to be hazardous, and many other new non hazardous transformers. Warehouse B also contained all of the HID lamps. "The Patio" contained the remainder of the PCB containing

transformers. The warehouses also had stored some of the company's new transformers, which were manufactured after 1977 and thus contained very low levels of PCBs.

Prior to our visit to the warehouse, 8 of ESPH's ~300 stored transformers had their oil tested for PCBs. Of the 8 tested, 4 tested positive for PCBs. Two of the stored PCB-containing transformers were leaking, as the sludge puddle on the ground in Figure 4 displays.

Figure 4: Image showing spilled transformer oil at ESPH's "The Patio" warehouse

Of the transformers that tested positive for PCBs, the transformer in the worst condition, in Figure 5, was leaking, had plastic over the top to reduce the release of PCBs into the environment, and was placed in a remote part of warehouse B.

Figure 5: Image showing a transformer containing PCBs in ESPH's Warehouse B

The HID lamps were stored in large boxes measuring 1.5 meters in height, width, and depth. The boxes that were stacked on top of each other, and according to the warehouse manager, the contained bulbs were broken, so he gave an estimate that the boxes held about 30,000 expired HID lamps. Figure 6 shows an example of an HID lamp with the glass structure broken and Figure 7 shows smaller bins containing a variety of expired HID lamps.

Figure 6: Image showing an example of a broken HID lamp in ESPH's warehouse A

Figure 7: Image showing expired lamps at ESPH's Warehouse B

4.2 Legal implications that may arise

ESPH is violating laws outlined by *Compenido de Legislacion Sobre Sanidad y Conservation Ambiental* (2001) regarding storage of hazardous materials that can get into the water supply and ground. The specific articles that pertain to ESPH in Costa Rican law can be found in Appendix A. By leaving PCB containing transformers in an open ceiling and concrete floor warehouse facility, the threat of PCBs entering the environment by air is high, especially since some of ESPH's PCB-oil containing transformers are leaking.

ESPH also violates laws regarding the storage of hazardous materials that can escape into the atmosphere, outlined by *Codigo Ambiental Internacional*, Costa Rica (2001). Both their PCB containing transformers and mercury containing HID lamps are stored in an open ceiling warehouse. By having these hazardous materials at this facility, ESPH also violates laws regarding proximity to residential areas (the warehouse is in a residential district, next to a school). A legal case study called *Estudio de Mechanismo de Solucion de Diferencias de la OMC en Controverseas de Comercio y Medio Ambiente en Relacion del NAFTA y la Union Europea* (1999) concludes that when environmental

agencies enforce environmental legislative laws, repercussions are severe. The case study dealt with workers and people living around a given company that had massive amounts of PCB equipped oil enter the environment because of improper storage practices. The workers, who were not adequately protected, experienced health problems that were induced by improper containment of the hazardous oils.

ESPH can, however, make the law work to its advantage. There are many incentives (tax breaks, accreditation, etc) for companies that dispose of their waste in an environmentally friendly manner and that contain minimal levels of hazardous materials in their facilities. By implementing feasible and environmentally conscious methods of waste removal ESPH, there is a great possibility that they could receive tax breaks from the government for their environmentally friendly efforts.

Our interview with Dr. Sergio Musmanni brought to our attention legislation regarding the import and export of hazardous waste. The *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal* (Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal, 2007, pp.1-75), is an international treaty ratified by all countries except the United States, Haiti, and Afganistan, the purpose of which is to prevent the transport of hazardous wastes from industrialized countries to developing countries. An outline of all relevant sections of the Basel Convention that pertain to ESPH is located in appendix B. Since PCBs are identified as hazardous wastes, proper steps must be taken in order to assure the legality of the exchange of hazardous transformers to remote places for disposal. The two focal points of the convention are the regulation of transportation of hazardous (and non-hazardous) wastes across borders as well as insuring that said wastes

are disposed of in an “environmentally sound manner” (United Nations Environmental Programme, 2006, ¶ 2). According to both Dr. Musmanni of CNP+L and Señora Aguirre of ICE, most PCB incineration companies such as AVR do all associated paperwork needed to show proof of compliance with The Basel Convention, so minimal complications are incurred to ship wastes out.

Also, from internet research done on shipping hazardous wastes overseas, it was found that any company shipping hazardous waste overseas must have the proper IMDG (International Maritime Dangerous Goods) coding for shipping waste to Europe. Also, the proper ADR (from the French abbreviation ***A****ccord européen relatif au transport international des marchandises* ***d****angereuses par* ***r****oute*) codes for transporting hazardous waste on land in Europe must be used. Both of these codes are stickers, such as the flammable waste diamond found on gasoline trucks, explicitly denoting that what is being transported is hazardous waste.

4.3 Changes to be made to handling and containment procedures

Because PCBs are human carcinogens, workers handling PCBs should exercise the utmost caution in procedures regarding their storage and disposal. Though the EPA does not have a specific guideline for their handling, there are general requirements set forth by OSHA to be followed when dealing with PCB-containing wastes. According to OSHA, humans can be exposed to PCBs through various forms of contact, including absorption through skin, inhalation, or through ingestion of contaminated foods. When

workers are required to share an environment with PCBs, employees should be provided with proper personal protection equipment. To protect against PCBs, equipment must first be suitable to prevent any kind of skin or eye contact with PCBs. This means that non-porous gloves, gauntlets, boots or shoe protection, aprons, or heavy overalls. For larger clean-up operations, a full suit of non-porous clothing may be necessary. Equipment exposed to PCB contaminants should be washed separately from normal work clothes. Respiratory equipment should be provided to prevent contamination through inhalation. Additionally, goggles or face shields should be provided to prevent the possibility of contaminated oils being splashed into workers' eyes (Communications Workers of America, 2004). All transformers should be tested with a 50 ppm (parts per million) Clor-in-Oil test, to determine which transformers have over 50 ppm PCB oil contained in them. Those that have over 50 ppm's are considered hazardous and should be contained and labeled so minimal levels of contamination occur.

From phone correspondence with Mercury Recycling PLC in the UK, it was explained that the best way to store a spent lamp is by saving the lamp's original packaging, and then putting the spent lamp into it for safe storage. From our interview with Dr. Musmanni, it was determined that when a mercury-containing lamp breaks, roughly 40% of the mercury is instantly released into the atmosphere, and the 60% that remains in the broken lamp slowly vaporizes and also enters the environment. Thus, in taking down the lamps, it is important to make sure that the lamps remain unbroken to preserve the contained mercury. If lamps do break, Mercury Recycling PLC suggested that the best option for containing the gases that remain in the bulbs is by placing them into a properly sealed 55-gallon drum.

4.4 Available waste management resources, procedures and costs for PCB-containing transformers

We identified a total of twelve potential companies through our interviews and web searching. There were some options which, upon investigation, could not be recommended as final solutions for PCB waste management. For PCB disposal, the options that were unfeasible were: land filling at the Alajuela or Guatemala City facilities and incineration at Holcim Geocycle, AVR International, Indaver, and SITA. This left only FTA Logistics and TREDI to be considered as feasible options for PCB removal for ESPH. Table 4, at the end of section 4.4, summarizes all of the following options for easy comparison.

4.4.1 Option 1 – Disposal using the WPP operated Alajuela Landfill

The first option we considered for management of ESPH's transformer oil was the Alajuela Landfill. This method was proposed by Professor Arietta in our interview with CICA. The company that manages the landfill, WPP, provides regional waste management for Alajuela and for surrounding areas, including Heredia. Information regarding WPP and its landfill was acquired through phone correspondence with the facilities office (506-433-8656) and by internet: www.wppcontinental.com/servicios.municipal.html (WPP, 2007, ¶ 1, 2, 3). The procedure to be executed for this option would involve creating a safe environment for PCB-containing transformer oil to be stored, in which wastes would be encapsulated in

specialized containers to assure that leaking canisters would not introduce hazardous elements into the environment. Currently, this landfill is not managed in a specialized manner to deal with hazardous wastes in this way, however; the company primarily deals with non-hazardous municipal waste. Cost for WPP's Alajuela waste management service is $.70 per kilogram, but a higher price is charged if machinery must be used for reasons such as moving heavy objects (Angela Malek, 2007).

Legal implications that would become a factor when employing this option are outlined in Articles 74, 278, 296, 304, and 305 of *Compenido de Legislación Sobre Sanidad y Conservación Ambiental*. Article 74 states there must be no way to contact the waste directly, so precautions must be taken by WPP employees to ensure that the PCB containing transformers do not directly come in contact with anything. Article 278 states that wastes must not have a way to escape into air, water, or ground-environments. ESPH has already violated this law by keeping the transformers (some open or leaking) in an open ceiling warehouse, and for the Alajuela landfill to comply with this law and be a viable waste removal option, it would need to have a measure by which it prevents waste from entering the atmosphere, a measure which it currently does not employ. Article 296 states that any proprietor hired by a company must be aware of environmental safety at the hiring company's expense and must contribute as little as possible to environmental pollution, which means ESPH must state that what is being landfilled is hazardous and must be properly contained and handled. Article 304 states that if wastes are able to permeate containment measures, a company must cease operations until that source of contamination is managed, which means that ESPH must either dispose of its waste now so its operations aren't stopped, or somehow the waste must be contained so if it is

moved to another place, such as the Alajuela landfill, it will be safe. WPP Alajuela cannot properly contain the materials since it is a municipal landfill and isn't designed to contain hazardous waste. Article 305 states that if the company's operations are performed in a rural environment, precautions must be taken in order to prevent detrimental influence to the environment, which in ESPH's case means that they need to either remove the waste or contain it until it can be safely land filled by WPP, because both the Alajuela landfill and ESPH are located on the border of a suburban/rural area of Costa Rica (Ivan Palacios Echverria Abogado, 2001).

Land filling at the Alajuela landfill should not be considered as a realistic option for disposal of PCB-containing transformers because the current management does not support procedures to deal with hazardous wastes. Because proper procedures for handling hazardous wastes are not emphasized at this facility, the wastes being disposed of would pose no less of a hazard to the people handling the waste or to the environment as they do in the state of storage that they currently are in now.

4.4.2 Option 2 – Disposal using the Guatemala City Landfill

The second option for management of ESPH's transformer oil is the Guatemala City Landfill located in Guatemala City, Guatemala. This method was proposed by Doctor Musmanni in our interview with CNP+L. The procedure for this option is to ship the PCB-containing waste to the Guatemala City Landfill, which is a hazardous waste landfill, a landfill with a specially engineered basin that prevents leakage of oils into the surrounding environment. Estimated costs for disposal in the Guatemala City Landfill are disposal were not disclosed to us by the Guatemala landfill because it now only offers its

services domestically. This landfill is engineered to receive hazardous wastes, but because the landfill is located in another country, ESPH would have to comply with international law to assure legal management of PCB waste. Specifically, companies exporting waste must comply with the Basel Convention, which is used to monitor the exchange of hazardous wastes on an international level *(*Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal, 2007, pp.1-75). Sections specific to Guatemala are marked in green in Appendix B of the report. Because Guatemala is relatively undeveloped when compared Costa Rica, legal allowances for this landfill were found to be limited to only domestic waste. Upon further investigation, it was found that two companies, one located in the UK, the other in Canada, violated the Basel Convention by shipping their wastes to a less developed country and were reprimanded with fines and lawsuits for millions of dollars (Business Wire, 2005, ¶ 3). To avoid the possibility of following the same fate as these companies, we stress that ESPH does not use this option.

Although the Guatemala City Landfill maintains systems to control hazardous wastes, legal factors present serious risk to the company in considering this option. As shown by case studies, sending wastes across borders to this facility would expose ESPH to severe ramifications due to The Basel Convention as well as international scrutiny. Use of the Guatemala City Landfill is thus considered unfeasible.

4.4.3 Option 3 – Incineration using Holcim Geocycle

The third option we considered for management of ESPH's PCB-containing transformer oil is incineration through Holcim Geocycle. Holcim is a company located in

Cartago, Costa Rica that manufactures cement (Holcim Geocycle, 2007, p.1). Because high temperature kilns (2000ºC) are required as a part of manufacture, the company owns and operates equipment that could be modified to incinerate PCB-containing transformer oil. This option was recommended to us both by our liaison, Señor Bolaños through personal correspondence, as well as by Dr. Musmanni in our interview with CNP+L. Contact information for Olman Navarro (olman.navarro@holcim.com, 506-552-8922) was provided by Dr. Musmanni for inquiry for more information on Holcim's ability to dispose of chlorinated hydrocarbon waste. Procedure for this method would involve modification of kilns to support an environment capable of completely burning off PCBs. Doctor Musmanni then clarified that Holcim is not currently developing plans for PCB disposal because the production of PCB-containing transformers has halted and thus there is presently not adequate financial incentive for the company to develop such procedures. Because services are not offered by this company, there is no way to know a cost estimate for disposal through Holcim.

Holcim Geocycle cannot currently be considered as a viable option because it lacks the facilities to operate and dispose of PCB-containing transformer oils. Though this option was recommended by multiple sources, the company is not in any stage of development to dispose of PCB-containing transformers, and thus no information could be obtained that supported this company's consideration of implementing such technologies. For this option to be considered feasible, all companies that have PCB-containing oils would have to pool their waste together and come to an agreement with Holcim saying that they would use its modified kilns to incinerate all of their PCB-

containing oils. As a result of the unfeasible nature of this option, legal implications will not be elaborated on.

4.4.4 Option 4 – Incineration using AVR International

The fourth option we considered for management of ESPH's transformer oil is incineration through AVR International. AVR is a company located in the Netherlands that offers management solutions of industrial and municipal level wastes. This option was recommended to us by Dr. Musmanni in our interview with CNP+L. Contact information for the company was provided by Dr. Musmanni (Tel: 01-18-127-3479). The procedure by which AVR would manage the waste would be by placing the PCB-containing oil in a high temperature kiln specifically designed to burn off the oil. Wastes would need to be shipped in order to be incinerated in facilities in Europe. Upon contact, we were informed that the company no longer incinerates liquid chlorinated hydrocarbons, however, and thus we could not receive a cost estimate for these once-performed services.

4.4.5 Option 5 – Incineration using FTA Logistics

The fifth option considered for management of ESPH's transformer oil is incineration through FTA Logistics. FTA Logistics is a hazardous wastes disposal company with many facilities all over Europe, and headquarters in the Netherlands. FTA Logistics offers PCB-containing oil disposal through incineration methods in specialized facilities to reduce generation of incomplete combustion byproducts, like dioxin. Wastes

would need to be shipped in order to be incinerated by FTA Logistics' facilities in the Netherlands (FTA Logistics, 2007, p. 3, 4, 7). Estimated costs for disposal are $4700-$5370/per metric ton and the bulk weight of the transformers consists of the transformer itself plus about 20% of its weight in packaging. This cost includes permit application, transport, disposal expenses, packaging and handling. This fee does not include any taxes that Costa Rica may apply for exportation. Because of the convenience of the services FTA Logistics provides, we consider it to be a feasible option for PCB removal.

Legal implications that would become a factor when employing this option are outlined in Article 74 of *Compenido de Legislacion Sobre Sanidad y Conservation Ambiental* and in other regulations specific to Europe. Article 74 states there must be no way that handlers can contact the waste directly, so precautions would have to be taken by FTA Logistics' employees to ensure that the PCB containing transformers and the oil being incinerated do not directly come in contact with any outside sources, which FTA Logistics does (Ivan Palacios Echverria Abogado, 2001). ESPH does not have to personally deal with most Basel Convention regulations because part of FTA Logistics' services are to ensure that all regulations are properly followed, and ESPH would need to fill out only minor shipping paperwork. The different outlines for the scope of the convention, general obligations, international co-operation, notes, and information to be provided on the movement document sections of the Basel Convention are outlined in appendix B. All regulations specific to Europe, IMDG (International Maritime Dangerous Goods) coding for hazardous waste shipping and ADR (***A****ccord européen relatif au transport international des marchandises* ***d****angereuses par* ***r****oute*) codes for hazardous waste land transporting will be taken care of by FTA Logistics.

4.4.6 Option 6 – Incineration using TREDI

The sixth option for management of ESPH's transformer oils is incineration through TREDI. TREDI is a hazardous waste management company with headquarters in Aukland, New Zealand, and recycling facilities throughout Europe (TREDI, 2007, p.1). Incineration would be utilized to dispose of the PCB wastes using high temperature kilns as incinerators. Shipping would have to be organized by ESPH to transport the wastes to the French disposal facility. Estimated costs for disposal are $4500 US per metric ton, and the bulk weight of the transformers consists of the transformer itself plus about 20% of its weight in packaging. This estimate includes shipping to the incinerator in France, packaging fees, handling fees, disposal fees, removal fees, but does not include any taxes that Costa Rica may implement for export. Like FTA Logistics, due to the services TREDI provides, it is considered to be a feasible option for PCB removal.

ESPH does not have to personally deal with most Basel Convention regulations because part of TREDI's services are to ensure that all regulations are properly followed, and ESPH would need to fill out only minor shipping paperwork. The different outlines for the scope of the convention, general obligations, international co-operation, notes, and information to be provided on the movement document sections of the Basel Convention are outlined in appendix B.

4.4.7 Option 7 – Incineration using Indaver

Though AVR was not able to offer costs for disposal, they were able to recommend another hazardous waste removal company, Indaver (2007, p. 1, 2). Thus, the seventh option considered for management of ESPH's transformer oil was incineration through Indaver, which specializes in industrial waste disposal. The company is centered in Belgium, but has satellite treatment sites all over Europe. The procedure that would be performed in this operation involves the incineration of PCB-containing oil through the use of specialized high temperature static kilns. Wastes would need to be shipped in order to be incinerated at Indaver's facilities in Europe. Estimated costs for disposal are not known because Indaver had not responded to phone calls and emails. Thus, it can not be considered as a feasible option because pricing is unknown.

ESPH does not have to personally deal with most Basel Convention regulations regarding shipping because part of Indaver's services are to ensure that all regulations are properly followed, and ESPH would need to fill out only minor shipping paperwork. The different outlines for the scope of the convention, general obligations, international co-operation, notes, and information to be provided on the movement document sections of the Basel Convention are outlined in appendix B.

4.4.8 Option 9 – Incineration using Veolia Environmental Services

The ninth option considered for management of ESPH's transformer oil is incineration through Veolia. Veolia, a subdivision of SITA, is company based in the UK. Like Indaver, Veolia offers PCB-containing oil disposal through incineration methods in

specialized facilities to reduce generation of incomplete combustion byproducts, like dioxin. Wastes would need to be shipped in order to be incinerated by Veolia's facilities in the Netherlands (Veolia, 2007, ¶ 1). Estimated cost for disposal is around $3,500-$4,000 US per metric tonne, when the weight being measured is comprised of the transformer itself plus about 20% of its weight in packaging. This cost includes permit application, transport, disposal expenses, packaging, and handling. This fee does not include any taxes that Costa Rica may apply for exportation. Because of the convenience of the services Veolia offers, the company is being considered as a feasible option for ESPH's PCB transformer removal.

ESPH does not have to personally deal with most Basel Convention regulations because part of Veolia's services are to ensure that all regulations are properly followed, and ESPH would need to fill out only minor shipping paperwork. The different outlines for the scope of the convention, general obligations, international co-operation, notes, and information to be provided on the movement document sections of the Basel Convention are outlined in appendix B.

A summary of the options considered for PCB transformer oil waste management are displayed on the next page in Table 4.

Table 4: Summary of PCB waste management options

Company Name	Company Location	Contact Information	Procedure	Cost	Legal Constraints*
WPP-operated Alajuela Landfill	Alajuela, Costa Rica	Phone: 506-433-86-56	Landfilling	$.70 US/ kg	Articles 74, 278, 296, 304, and 305
Guatemala City Landfill	Guatemala City, Guatemala	Jorge Mario Solares, Phone: 502-251-57-97	Hazardous Waste Landfilling	N/A	The Basel Convention
Holcim Geocycle	Cartago, Costa Rica	Olman Navarro, Phone: 506-552-89-22, olman.navarro@holcim.com	Incineration	N/A	Articles 26, 66, 70, 74, 294, 297, and 305
AVR Intl.	Rotterda Netherlands	Mr. Yambuli, Phone: 000-118-127-34-79	Incineration	N/A	Basel Convention and Article 74
FTA Logistics	Alblasslerdam, Netherlands	Bea Ruscillo, Phone: 3-118-062-21-75, bea@ftalogistics.com	Incineration	$4698.75-$5370 US/ Tonne	Basel Convention and Article 74
TREDI	Penrose, Aukland, New Zealand	Boyne Drummond, G.M., Phone: 649-525-15-50, tredi@tredi.co.nz	Incineration	$4500 US/ Tonne	Basel Convention and Article 74
Indaver	Antwerp, Belgium	Mr. Edvin Coppens, Phone: 003-247-330-17-05, e.coppens@ekodeko.com	Incineration	N/A	Basel Convention and Article 74
Veolia	Bogota, Colombia rep	Phone: 0-177-263-18-19, Gabrielle.Chifflier@veoliauk.com	Incineration	N/A	Basel Convention and Article 74
*References for all articles can be found in Appendices A and B.					

4.5 Available waste management resources, procedures and costs for mercury-containing HID lamps

Initially, there were 9 options found for managing HID lamps. However, there were some options that upon investigation could not be recommended as final solutions for current HID lamp waste management. For HID lamp disposal, the options that were unfeasible were land filling at the Alajuela or Guatemala City facilities and recycling

using Mercury PLC, Bulb Eaters, Resource Technology, or Indaver. This left Bethlehem Apparatus Co., Inc., FTA Logistics, and TREDI to be considered as feasible options for HID lamp removal for ESPH. Table 5, at the end of section 4.5, summarizes all of the following options for easy comparison.

4.5.1 Option 1 – Disposal using Alajuela Landfill

The first option for management of ESPH's mercury-containing HID lamps is by land filling through the Alajuela regional landfill. Contact information we used to gain information on landfilling of the bulbs was the same used to get information for land filling PCB-containing transformer oil (506-433-8656), and internet: www.wppcontinental.com/servicios.municipal.html (WPP, 2007, ¶ 1, 2, 3). In this process, unbroken bulbs (if there are any) would be stored in their original packaging and then put into a containment unit to serve as a suitable container. Broken bulbs would have to be placed in a different container sealed in a way that prevents wastes from escaping into the environment. Cost for WPP's Alajuela waste management service is $.70 per kilogram, but a higher price will be charged if machinery must be used for reasons such as moving heavy objects (Angela Malek, 2007).

Legal implications that would become a factor when employing this option are outlined in Articles 74, 278, 296, 304, and 305 of *Compenido de Legislación Sobre Sanidad y Conservación Ambiental*. Article 74 states there must be no way to contact the waste directly, so precautions would have to be taken by WPP employees to ensure that the HID lamps do not directly come in contact with anything. Article 278 states that wastes must not have a way to escape into air, water, or ground environments. Since

ESPH has already violated this law by keeping the transformers (some open or leaking) in an open ceiling warehouse, and for the Alajuela landfill to comply with this law and be a viable option, it would need to prevent waste from entering the environment, which the landfill does not currently do. Article 296 states that any proprietor hired by a company must be aware of environmental safety at the hiring company's expense and must contribute as little as possible to environmental pollution, which means ESPH must state that what is being land filled is hazardous and must be contained and handled. Article 304 states that if wastes are able to permeate containment measures, a company must cease operations until that source of contamination is managed, which means that ESPH must either dispose of its waste now so its operations aren't stopped, or somehow the waste must be contained so it will not leak when it enters the Alajuela landfill, which WPP Alajuela cannot properly do since it is a municipal landfill and isn't designed to contain hazardous waste. Article 305 states that if the company's operations are performed in a rural environment, precautions must be taken in order to prevent detrimental influence to the environment, which in ESPH's case means that they need to either remove the waste or contain it until it can be safely land filled by WPP, because both the Alajuela landfill and ESPH are located on the border of a suburban/rural area of Costa Rica (Ivan Palacios Echverria Abogado, 2001).

Land filling at the Alajuela landfill should not be considered as a realistic option for disposal of mercury-containing HID lamps because the current management does not support procedures to deal with hazardous wastes. Because proper procedures for handling hazardous wastes are not emphasized at this facility, the wastes being disposed

of would pose no less of a hazard to the people handling the waste or to the environment as they do in the state of storage that they currently are in now.

4.5.2 Option 2 – Disposal using Guatemala Hazardous Landfill

The second option for management of ESPH's mercury-containing lamps is exporting lamps to be land filled in the Guatemala City Hazardous Waste Landfill. This method was proposed by Professor Arietta in our interview with CICA. Contact information used was identical to that used for inquiry on PCB land filling (Jorge Solares, 502-251-5797). In this process, unbroken bulbs would be stored in their original packaging and then placed into a containment unit to serve as a suitable container to prevent breakage. Broken bulbs would have to be stored in a different container sealed in a way that it prevents wastes from escaping into the environment. Again estimated costs for disposal were not disclosed to us by the Guatemala landfill because it is restricted to domestic use only. Legal implications that would become a factor when employing this option are the Basel Convention, which is used to monitor the exchange of hazardous wastes on an international level. Because Guatemala is relatively undeveloped when compared to industrialized countries, legal allowances for this landfill were found to be limited only to domestic waste.

Although the Guatemala City Landfill maintains systems to control hazardous wastes, legal factors present serious risk to the company in considering this option. As shown by case studies, sending wastes across borders to this facility would expose ESPH to severe ramifications due to The Basel Convention as well as international scrutiny *(*Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and

Their Disposal, 2007, pp.1-75). Specific sections of the Basel Convention specifically regarding Guatemala are highlighted in green in outline of the Basel Convention in appendix B. Use of the Guatemala City Landfill is thus considered unfeasible.

4.5.3 Option 3 – Recycling using Mercury Recycling PLC

After being informed by Professor Arrieta and Doctor Musmanni that there are no mercury lamp recycling solutions available in Costa Rica, internet searches were done for international companies that would provide such services. One of these companies, centered in the UK, is called Mercury Recycling PLC and has been recycling mercury lamps (fluorescent and HID lamps) since the construction of its first lamp recycling facility in 1996. Since then, the company has become the largest dedicated lamp recycling facility in the UK, with the capacity to recycle 40 million lamps per year (Mercury Recycling PLC, 2007, ¶ 4). The way the service works is that the company sends a package to be filled with lamps, and then the package is picked up and sent to the recycling facility. Upon arrival at the facility, the lamp is introduced into a cold, sealed chamber, where the mercury is extracted from the bulb, and the chamber is then pressurized to condense the mercury. The glass and metal remnants are then land filled. The mercury recovered by the procedure is then sold to be reused. Official documentation showing that the mercury was recycled is then sent to the company being provided the service (Mercury Recycling PLC, 2007, ¶ 2, 3, 4).

Upon interviewing Mercury Recycling PLC by phone, it was determined that the packaging could not be shipped to Costa Rica because the company does not ship packaging overseas. In fact, the phone representative stated that “the logistics of sending

poorly contained broken HID lamps overseas in such a quantity would be a nightmare," and that our best option is to make use of portable technologies, such as the Bulb Eater. Because of the difficult logistics of using Mercury Recycling PLC's services, the company refused to give a cost estimate for ESPH's lamps. (Mercury Recycling PLC, 2007) Thus, using this company as a viable option for HID lamp removal is being considered unfeasible.

4.5.4 Option 4 – Volume Reduction and Recycling using Bulb Eaters

Doctor Musmanni highly recommended employing the use of Bulb Eaters, a compact and portable design produced in the UK by a company called Aircycle that would eliminate large volume shipping arrangements. The apparatus, which would be purchased by ESPH, forms a closed loop system of disposing bulbs that contain mercury. The system consists of a 55 gallon drum and a device that latches to the top that breaks the glass, and at the same time provides a vacuum to pull the mercury gases through a charcoal HEPA filter. The glass is collected by the 55 gallon drum, which holds roughly 1500 of the four-foot-long and one-inch-diameter lamps. Since this is a closed loop system, there is no way for the mercury to be released, and the glass and metal residue from the bulbs are sent back to the Aircycle factory to be recycled. The charcoal filter as well is sent back to the factory when spent and new filters are bought, all being done on a timed interval determined by the factory. Unfortunately, it was determined that Bulb Eaters only process fluorescent lamps, so they cannot be applied to the specific case at hand for ESPH and are thus considered an unfeasible method of recycling. However, if

ESPH chose to recycle its fluorescent lamps, this would be a viable option to employ. The cost of a single bulb-eater apparatus is $3,160 (Aircycle, 2007, p.1).

Should ESPH eventually use this machine for fluorescents, legal implications that would become a factor when employing this option are outlined in Article 74 of *Compenido de Legislacion Sobre Sanidad y Conservation Ambiental* Article 74 states there must be no way to contact the waste directly, so precautions would need to be taken by ESPH's employees feeding the bulbs into the machine to ensure that the HID lamps and the mercury being recycled do not directly come in contact with either any outside sources or the workers themselves (Ivan Palacios Echverria Abogado, 2001). ESPH must take into account the Basel Convention regulations , because, although Bulb Eaters provides packaging for spent filters, the filters themselves need to be sent safely to a recycling facility because of the mercury content they would possess (Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal, 2007, pp.1-75)ye. The different outlines for the scope of the convention, general obligations, international co-operation, notes, and information to be provided on the movement document sections of the Basel Convention are outlined in appendix B.

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4.5.5 Option 5 – Volume Reduction and Recycling using Resource Technology

Another type of "bulb eater" explored was the Resource Technology bulb eater model LSS1, found at Resource Technology, based in Wisconsin, USA. This was discovered by a generic "bulb eater" search on Google, to find any competitors to the actual Bulb Eater product. Unlike the Bulb Eater, this machine is gigantic; 3.7 meters

high by 9.15 meters long 4.56 meters wide. Lamps are fed into the system by an operator, and the closed loop system breaks the lights without allowing the mercury contained in the lamps to exit into the environment. This is achieved by a vacuum seal, which draws the mercury into charcoal and HEPA filters once the lamps are broken (Resource Technology, 2007, p. 1, 2). Unfortunately, this machine does not accept HID lamps either, just like the Bulb Eater, and is thus not a feasible option for HID lamp removal. However, if ESPH chose to recycle its fluorescent lamps, this would be a viable option to employ. This machine costs upwards of $65,000 US.

Legal implications that would become a factor when employing this option are outlined in Article 74 of *Compenido de Legislacion Sobre Sanidad y Conservation Ambiental*, in conditions provided in the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal, and in other regulations specific to Europe. Although this machine is made in the USA, because the country did not ratify the Basel Convention, the mercury containing filters would have to be delivered elsewhere unless otherwise dictated by the United States, which is also outlined in the Basel Convention on the Control of Transboundary Movement of Hazardous Waste. The filters themselves need to be sent safely because of the mercury content they would possess (Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal, 2007, pp.1-75). The different outlines for the scope of the convention, general obligations, international co-operation, notes, and information to be provided on the movement document sections of the Basel Convention are outlined in appendix B. Article 74 pertains to Resource Technology the

same way as Aircycle's Bulb Eaters, which is explained above (Ivan Palacios Echverria Abogado, 2001).

4.5.6 Option 6 – Recycling using Bethlehem Apparatus Co., Inc.

When Aircycle explained that Bulb Eaters were not a viable solution for HID lamps, the phone representative then recommended "The Bethlehem Apparatus." Bethlehem Apparatus Company, located in Pennsylvania in the USA, is the world's largest commercial recycler of mercury bearing waste. As such, the company is capable of handling a wide variety of mercury bearing wastes, and can safely recycle HID lamps containing mercury. Bethlehem Apparatus Co. is a very highly certified company, as its website dictates:

> "We meet or exceed all local, state, federal, and EPA regulations at every step of the recovery operation." (Bethlehem Apparatus Co., Inc., 2007, ¶ 2)

Upon contacting Bethlehem Apparatus, we were given a cost estimate for the provision of recycling services for ESPH's 30,000 broken HID lamps. $2.75 per pound of lamps, but all shipping arrangements are ESPH's responsibility. Thus, because Bethlehem has an impeccable reputation and gave a price for HID lamp recycling, the company is being considered a feasible option for ESPH's HID lamp recycling.

Legal implications that would become a factor when employing this option are outlined in Article 74 of *Compenido de Legislacion Sobre Sanidad y Conservation Ambiental* and in conditions provided in the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal. Bethlehem Apparatus Co is a US company, and since by choosing this option ESPH would be

shipping its wastes to a non-Basel Convention signed country, it would be required to adhere closely to the Basel Convention sections that pertain to shipping and doing business with a non-Basel Convention signing companies (Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal, 2007, pp.1-75). The different outlines for the scope of the convention, general obligations, international co-operation, notes, and information to be provided on the movement document sections of the Basel Convention are outlined in appendix B.

4.5.7 Option 7 – Recycling using TREDI

The fourth option considered for management of ESPH's HID lamps was removal through TREDI. TREDI, as mentioned above, is a hazardous waste management company with headquarters in Aukland, New Zealand, and removal facilities throughout Europe. TREDI would dispose of the lamps by first utilizing mercury remediation from the glass in a sealed and controlled space, and since it is a vacuum sealed room, the only remaining substances would be glass, plastic, and metal. TREDI then removes these cleaned byproducts, either by disposal or recycling (TREDI International, 2007, p.1). Considerations for shipping the waste must be organized in order to deliver the waste to the disposal facility in France. Estimated costs for disposal are $9 US per pound, and the bulk weight of the HID lamps are comprised of the lamp itself plus about 50% of its weight in packaging. This estimate includes shipping to the incinerator in France, handling fees, disposal fees, removal fees, but does not include any taxes that Costa Rica may implement for export. Because of the convenience of contracting through TREDI to

remove HID lamps, it is being considered as a feasible option for ESPH's HID lamp removal.

ESPH does not have to personally deal with most Basel Convention regulations because part of TREDI's services are to ensure that all regulations are properly followed, and only minor shipping paperwork would be needed. The different outlines for the scope of the convention, general obligations, international co-operation, notes, and information to be provided on the movement document sections of the Basel Convention are outlined in appendix B.

4.5.8 Option 8 – Recycling using FTA Logistics

The eighth option to be considered for management of ESPH's HID bulbs is recycling and remediation through FTA Logistics. As stated above, FTA Logistics is a hazardous wastes disposal company with many facilities all over Europe, and headquarters in the Netherlands. FTA Logistics reclaims mercury in a vacuum sealed space, by sucking the mercury from the bulbs, which enter filters and can be extracted for resale. All that is left is glass, plastic, and metal, which they either landfill of or recycle, depending on what is appropriate (FTA Logistics, 2007, p. 3, 4, 7). Wastes would need to be shipped in order to be recycled FTA Logistics' facilities in the Netherlands. Estimated costs for disposal are $10,740-12,082.5/metric ton and the bulk weight of the HID lamps is comprised of the lamp itself plus about 50% of its weight in packaging. This cost includes permit application, transport, disposal expenses, packaging, and handling. This fee does not include any taxes that Costa Rica may apply for exportation. Because of the

convenience of the services FTA Logistics offers, the company is being considered as a feasible option for ESPH's HID lamp removal.

ESPH does not have to personally deal with most Basel Convention regulations because part of FTA Logistics' services are to ensure that all regulations are properly followed, and only minor shipping paperwork would be needed to be completed by ESPH. The different outlines for the scope of the convention, general obligations, international co-operation, notes, and information to be provided on the movement document sections of the Basel Convention are outlined in appendix B.

4.5.9 Option 9 – Recycling using Indaver

The ninth option to be considered for management of ESPH's HID lamp removal was recycling through Indaver. In addition to PCB disposal, Indaver also offers solutions for disposal of mercurial wastes, such as those presented in the HID lights that ESPH is currently stockpiling. This operation is performed at their Relight facility in Beveren, Belgium. To recycle bulbs, a perforation flame is used to breach the tubes vacuum and mercury is removed using selective air injection. In this process lamps are crushed allowing glass and mercury powder to be separated from other materials. The materials recovered are either used for new glass bulbs or steel is sold as scrap metal. The Mercury powder is treated separately using ecological processes (Indaver, 2007, p. 1, 2). Estimated costs for disposal are not known because Indaver had not responded to us, and thus, the company cannot yet be considered to be a viable option for HID lamp removal. If ESPH is interested in finding pricing information from Indaver, future contact attempts with this company are recommended.

ESPH does not have to personally deal with most Basel Convention regulations because part of Indaver's services are to ensure that all regulations are properly followed, and only minor shipping paperwork would be needed to be completed by ESPH. The different outlines for the scope of the convention, general obligations, international co-operation, notes, and information to be provided on the movement document sections of the Basel Convention are outlined in appendix B.

A summary of the options considered for HID lamp waste management are displayed in Table 5.

Table 5: Summary of HID lamp waste management options

Company Name	Company Location	Contact Information	Details	Cost	Legal Constraints*
WPP-operated Alajuela Landfill	Alajuela, Costa Rica	Phone: 506-433-8656	Landfilling	N/A	Articles 74, 278, 296, 304, and 305
Guatemala City Landfill	Guatemala City, Guatemala	Jorge Mario Solares, Phone: 502-251-57-97	Hazardous Waste Landfilling	N/A	The Basel Convention
Mercury Recycling PLC	United Kingdom	Phone: 44-161-877-09-77, sales@mercuryrecycling.co.uk	Mercury Recycling	N/A	IMDG/ADR, the Basel Convention, and Article 74
Bulb Eaters	United Kingdom	Phone: 800-909-97-09	Mercury Recycling using mobile unit	$3,160 US/disposal unit	Articles 70, 74, 278, 293
Resource Technology	Janesville, Wisconson, USA	Phone: 608-314-39-99, info@lampequipment.com	Mercury Recycling using mobile unit	$65,000+ US/disposal unit	Articles 70, 74, 278, 293
Bethlehem Apparatus Co., Inc.	Hellertown, PA 18055 USA	Jerry C. Odenwelder, Phone: 1-610-838-70-34, jerryo@bethapp.com	Mercury Recycling	$6.03 US/ kg	IMDG/ADR, the Basel Convention, and Article 74
TREDI	Penrose, Aukland, New Zealand	Boyne Drummond, Phone: 649-525-15-50, tredi@tredi.co.nz	Mercury Recycling	$19.84 US/ Kg	Basel Convention and Article 74
FTA Logistics	Alblasslerdam, Netherlands	Bea Ruscillo, Phone: 3-118-062-21-75, bea@ftalogistics.com	Mercury Recycling	$10740-$12083 US/ Tonne	Basel Convention and Article 74
Indaver	Beveren, Belgium	Mr. Bartholomew Goethalf, Phone: 00-32-35-70-73-60, bart.goethalf@indaver.be	Mercury recycling	N/A	IMDG/ADR, the Basel Convention, and Article 74
*References for all articles and the Basel Convention can be found in Appendix A and B.					

5. Conclusion

From our research, several conclusions were drawn that resulted in formulation of better practices for ESPH's handling, storage, and removal of PCBs and HID lamps. From our quantitative assessment, it was found that there were an estimated 300 untested transformers and an estimated 30,000 HID lamps in ESPH's warehouses. Some of the transformers are open-topped or leaking, and the majority of the lamps are broken and contained in three large cardboard boxes. Because of this, it is recommended that ESPH implements better handling procedures, which were also researched as part of our project.

For PCB transformers, it is recommended that ESPH uses Clor-N-Oil 50 testing kits in order to safely determine the PCB content in transformers. It is also suggested that while this testing or while handling of potentially PCB-contaminated transformer oils are being handled is being conducted, proper protective equipment including gloves, gauntlets, aprons, goggles, boots, and proper respiratory masks equipped with HEPA filters are worn.

For HID lamp handling and storage, it is suggested that the lamps are kept intact in order to prevent the release of mercury gases into the environment. To do this, the packaging in which the original lamp came should be used to safely store the unbroken lamps after they are taken down. If lamps are broken, 40% of the mercury contained will escape instantly, and in order to best contain the remaining 60%, it is suggested that the lamps are placed into a properly sealed 55 gallon drum. Options for properly disposing of both wastes are discussed in following paragraphs.

For disposal of PCBs and HID lamps, the options presented in the results were compiled based on expert advice and research of companies on the internet, but not every option listed is a feasible system of management. In some cases, the company does not currently or no longer performs the procedures of desired waste management. There were some companies that we were unable to receive information from regarding costs and paperwork. And other options posed serious legal violations. It is from these results that we will present a more precise list of recommendations (see Tables 6 and 7).

Table 6: Recommendations for PCB removal

Company	***Services Provided***	***Quoted Price***
FTA Logistics	-Permit application -Transport -Disposal Expenses -Packaging -Handling	$4,698.75- $5,370 US/tonne*
TREDI	-Shipping to facility (France) -Handling fees -Disposal fees -Removal fees	$4,500 US/tonne*
Veolia	-Shipping to facility (Netherlands) -Handling fees -Disposal fees -Removal fees	$3,500 - $4,000 US/tonne*

*Costs do not include taxes that may be applied by the state of Costa Rica

Table 7: Recommendations for HID lamp removal

Company	***Services Provided***	***Quoted Price***
FTA Logistics	-Permit application -Transport -Disposal -Packaging -Handling	$10,740-$12,082.50 US/tonne* (approx 4.87-$5.48/tonne)
TREDI	-Handling fees -Disposal -Removal Fees	$19.84 US/kg*
Bethlehem Apparatus	-Disposal (does not offer transport services)	$6.03 US/kg*

*Costs do not include taxes that may be applied by the state of Costa Rica

From working at ESPH and seeing the constant state of activity on the part of its workers, it is clear that the most convenient solution for hazardous waste disposal would be most beneficial to ESPH. With this in mind, it is not necessarily the lowest cost that stands as the best option to ESPH; convenience and ease of disposal should be taken into consideration when taking action to dispose of the selected hazardous wastes.

5.1 PCB Disposal

As is evident in Table 6, there are three options that were determined to be feasible in the disposal of PCB waste for ESPH. All three companies are located in Europe, so in order to dispose of the PCB wastes, the wastes must be shipped internationally. The services these three companies provide are similar, but specific costs were unable to be determined because at this time, quantity and weight of transformers that would need to be shipped was not able to be determined in the given amount of time. Because Veolia's services offer such a low price compared to the other researched sources, we have decided to give Veolia as our final recommendation to ESPH for PCB disposal.

5.2 HID Disposal

Though Bethlehem Apparatus offers the lowest price per pound, when considering shipment it must also be considered that the company operates in the United States, rather than in Europe like other suggested options. Additionally, the cost presented does not include all costs, since Bethlehem Apparatus does not arrange for

shipping and handling of the waste to be disposed at its facility. Clearly, though this option is feasible, it is not the best option to be considered in lieu of other alternatives. Because the relative quantity of bulbs to be disposed of is less than that of the transformers, we find it reasonable to suggest that TREDI be chosen to dispose of the waste even though their estimate for bulb disposal is nearly twice the cost per pound as that offered by FTA Logistics.

5.3 For further investigation

Though the group did its best to compile a comprehensive list of options for disposal of wastes, there were some contacts that did not respond to phone and email contact attempts. Additionally, there is the potential for projects to develop in the near future to effectively deal with the selected wastes in a manner that would be less laborious to the company.

Both Indaver and SITA did not respond back to us after they were contacted by email and phone in the interest of acquiring pricing and service information. Contact info for both of these companies can be found in the results section where they are discussed as possible options for disposal.

Currently, Holcim Geocycle does not offer PCB disposal services because it has not developed the technology to perform incineration with its cement kilns. This could, however, change if in the future enough of a financial incentive warrants the development of said procedures.

Because of time and other limiting factors, the scope of this project did not encompass all aspects regarding waste removal for ESPH. In addition to the remaining

hazardous wastes that have not been addressed, there are other aspects that should be considered in the case of continuation on the work of disposal of ESPH's wastes.

It has been identified that ESPH is a relatively small company. It is from this idea that it only makes sense that ESPH make effort in order to collaborate with companies that develop similar types of wastes. In the current situation, there are no waste management sources in Costa Rica, meaning that the only method for disposal is through exporting the waste to Europe. Because shipping is included in pricing for disposal, it is more efficient to send larger quantities of wastes collected from multiple companies. Similarly, because ESPH has a smaller quantitative demand for equipment such as Clor-n-oil testing kits, cooperation with other companies should be investigated to make costs for importation and use of such equipment more feasible for the company.

Weights of the respective wastes are needed in order to determine total costs of disposal. At this point in time, ESPH has not quantified total weights. Because of the variability between transformers in the weight of oil they contain, it is nearly impossible to estimate based on the weight of one transformer; ESPH has expired transformers that contain varying levels of oil.

5.4 Closing Remarks

The goal of any IQP is to do something that will positively benefit the community. Though the social aspects of our project may not have been as obvious as others, there is no denying that if we did not tackle ESPH's challenge with hazardous wastes, the stockpile of PCB transformers and HID bulbs contained by ESPH would do nothing but grow in size. We have established that these wastes cause serious harm when

they are allowed to be exposed. By emphasizing best practices for waste management we effectively helped in the prevention of exposure of the selected wastes to not only the workers, but to the surrounding community. Because of our involvement with ESPH, the management in charge of making important decisions regarding workers' safety is better informed of the threat that the wastes stored in the warehouses pose, and hopefully can use that information to make environmentally responsible decisions in the future.

6. Appendices

6.1 Appendix A: Compenido de Legislacion Sobre Sanidad y Conservation Ambiental: Relevant Articles

ESPH has unfortunately not fulfilled all legal requirements of running a facility containing hazardous waste. Here is a list of articles to which ESPH could conform.

From the Job Hygiene and Sanitation Section;

- Article 26 states that any operators cleaning dangerous residuals should be provided with protective equipment by the employer company.

From the Municipalities Section (which explicitly states in the opening paragraph of the laws that it is the proprietor's or company's obligation to acclimate all their actions, practices, etc, for the good of the environment and the public, above all other needs and priorities of the company);

- Article 32 states that in an area of development, any contaminates, black water, or waste in the terrain should be constantly monitored and contained so it doesn't reach the households the municipality works for. Article 48 states that any company not complying with any of the health hazards mentioned are to be immediately shut down immediately upon orders by the government Ministry of Health.

- Article 66 states that a company must not have substances in their buildings in amounts that will affect the health of any general (not trained to work with hazardous wastes, not equipped with the proper safety equipment, etc) workers.
- Article 70 states that if dangerous gases or vapors escape, there must be some evacuation procedure, with emphasis on personal safety.
- Article 74 states that the packaging, transporting and/or manipulation of hazardous wastes to be disposed of, there must be no way to contact the waste directly, there must be specific hazardous waste protective devices used to deal with the waste, repertory masks if needed, the environment the waste is shipped in must be completely contained so it doesn't enter the environment, etc.

From the Facilities in Developed Areas Section;

- Article 276 states that any company located proximal to living quarters must do any and all things to maintain the public, such as completely containing hazardous materials, conforming with the neighborhood on issues, addressing any concerns by neighbors, etc.)
- Article 278 states that all solid hazardous wastes must be collected and put in an environment where it cannot escape into the air, ground, or water.
- Article 282 states that once the Ministry finds any activities breeching the laws of the Facilities in Developed Areas Section pertaining to said company, the Ministry will create a timeframe for which a company must configure their company to conform to regulations.
- Article 293 states that a company must do everything in its power to prevent contamination of the environment.

- Article 294 states that if there exists any air contaminates in the form of fumes, vapors, solids, gases, etc then a company will have to conform to international and national laws to contain and rid of them.
- Article 295 states that not complying with the international and national laws governing airborne contaminates are subject to immediate closure if found negligent.
- Article 296 states that any outside proprietor hired by a company must be aware of environmental safety at the hiring company's expense and must contribute as little as possible to environmental pollution.
- Article 297 states that no building can have waste that contributes to the destruction of the atmosphere, especially in conditions where there is the heightened chance of affecting surrounding people or the environment.
- Article 302 states that any company that builds up hazardous waste from its operations must maintain these systems to the fullest extent so contamination doesn't occur.
- Article 304 states that if the Ministry finds the company to be negligent of preventing hazardous waste from contaminating areas within the vicinity of people, the company will be suspended indefinitely until it can complete the regulations set up by the Ministry.
- Article 305 states that, if in a rural environment, precautions should be taken so the environment is not affected by any hazardous waste the company may possess.

From the Penal Code Section;

- Article 413 states that all companies have a 15 to 30 day timeframe to properly address and maintain any gases, vapors or fumes that cause public or health concerns and/or eliminate wastes that are contaminating the environment

Ivan Palacios Echverria Abogado (2001)

6.2 Appendix B: The Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal: Relevant Sections

Scope of the Convention

1. "Hazardous wastes" that are subject to transboundary movement shall be:

Wastes that belong to any category in Annex I (Y6: Wastes from production, formulation and use of organic solvents, Y9: Waste oils/water, hydrocarbons/water mixtures, emulsions, Y10: Waste substances and articles containing/contaminated with polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs), Y18: Residues from industrial waste disposal, Y29: Mercury; mercury compounds, Y39: Phenols; phenol compounds including chlorophenols, Y41 : Halogenated organic solvents),

Unless they do not possess characteristics in Annex III (4.3: H4.3-Substances/wastes which, by interaction with water, are liable to become spontaneously flammable or give off flammable gases in dangerous quantities, 6.1: H6.1-Poisonous (Acute), 6.2: H6.2-Infectious substances, 9: H10-Liberation of toxic gases in contact with air or water, H11-Toxic (Delayed or chronic), H12-Ecotoxic, H13-Capable, by any means, after disposal,

of yielding another material, e.g., leachate, which possesses any characteristics listed above.).

General Obligations

Parties exercising the right to prohibit import of hazardous wastes or other wastes for disposal shall inform other Parties of their decision pursuant to Article 13. Parties shall prohibit/shall not permit export of hazardous wastes and other wastes to Parties which have prohibited imports of such wastes, when notified pursuant to the first sentence in the paragraph. Parties shall prohibit/shall not permit export of hazardous wastes/other wastes if the State of import doesnt consent in writing to specific import, in which case the State of import hasnt prohibited import of wastes.

2. Each Party shall take appropriate measures to:

Ensure that generation of hazardous wastes/other wastes within it is reduced to a minimum, taking into account social, technological, economic aspects. Ensure availability of adequate disposal facilities, for environmentally sound management of hazardous wastes/other wastes that shall be located within the place of their disposal. Ensure that persons involved in management of hazardous wastes/other wastes it take such steps necessary to prevent pollution due to hazardous wastes/other wastes from such management and, if pollution occurs, to minimize consequences for human health and the environment. Ensure that transboundary movement of hazardous wastes/other wastes is reduced to minimum consistent with environmentally sound/efficient management of wastes, and is conducted in a manner which protects human health and the environment against adverse effects which may result from movements. Not allow export of hazardous wastes/other wastes to a State/group of States belonging to an economic and/or political

integration organization that, particularly developing countries, which prohibited legislatively all imports, or if it has reason to believe that waste in question wont be managed in an environmentally sound manner, by criteria to be decided on by Parties at their first meeting; Guatemala. Require that information about proposed transboundary movements of hazardous wastes/other wastes be provided to States concerned, according to Annex V A, to state clearly effects of the proposed movement on human health and the environment. Prevent import of hazardous wastes and other wastes if it has reason to believe that wastes in question will not be managed in an environmentally sound manner. Co-operate in activities with other Parties/interested organizations, including dissemination of information on transboundary movement of hazardous wastes/other wastes, to improve environmentally sound management of such wastes/to prevent illegal traffic.

3. The Parties consider that illegal traffic in hazardous wastes or other wastes is criminal.

4. Each Party shall take appropriate legal, administrative and other measures to implement and enforce provisions of the Convention, including measures to prevent/punish actions against the laws of the Convention.

5. A Party shall not permit hazardous wastes/other wastes to be exported/imported to/from a non-Party.

7. Each Party shall:

Prohibit all persons under national jurisdiction from transporting/disposing of hazardous wastes/other wastes unless persons are authorized/allowed to perform such operations. Require that hazardous wastes/other wastes that are subject of a

transboundary movement be packaged, labelled, and transported in conformity with accepted and recognized international rules and standards in packaging, labelling, and transport, relevant to internationally recognized practices. Require that hazardous wastes/other wastes be accompanied by a movement document from point at which a transboundary movement commences to point of disposal.

8. Each Party shall require that hazardous wastes/other wastes to be exported are managed in an environmentally sound manner.

9. Parties shall take appropriate measures to ensure that transboundary movement of hazardous wastes/other wastes only be allowed if:

The State of export does not have the technical capacity and the necessary facilities, capacity or suitable disposal sites in order to dispose of the wastes in question in an environmentally sound and efficient manner; Guatemala. The wastes in question are required as a raw material for recycling or recovery industries in the State of import. The transboundary movement in question is in accordance with other criteria to be decided by the Parties, if the criteria doesnt differ from the objectives of this Convention.

10. The obligation under the Convention in which hazardous wastes/other wastes are generated require that the wastes are managed in an environmentally sound manner may not under any circumstances be transferred to the States of import/transit.

Transboundary Movement between Parties

1. The State of export shall notify and require the exporter to notify in writing, through the authority of the State of export, the authority of States concerned of transboundary movement of hazardous wastes or other wastes. Notification contains

declarations and information specified in Annex V A, written in an acceptable language. Only one notification needs to be sent to whoever concerned.

2. The State of import shall respond to the notifier in writing, consenting to the movement with/without conditions, denying permission for movement, or requesting additional information. A copy of the final response shall be sent to States concerned.

3. The State of export shall not allow the exporter to commence transboundary movement until recieving written confirmation that: The notifier has received written consent of the State of import, and the notifier has received confirmation from the State of import of existence of a contract between exporter and disposer specifying environmentally sound management of given wastes.

4. Each State of transit shall acknowledge receipt of notification. It may respond to the notifier in writing within 60 days, consenting to movement with/out conditions, denying permission for movement, or requesting additional information. The State of export shall not allow transboundary movement to commence until recieving written consent of the State of transit. If at any time a Party decides not to require prior written consent for transboundary movements of hazardous wastes or other wastes, or modifies its requirements, it shall inform the other Parties of its decision pursuant to Article 13. If no response is received within 60 days the State of export may allow the export to proceed through the State of transit.

5. In the case of a transboundary movement of wastes where the wastes are legally defined/considered to be hazardous wastes only: By the State of export, requirements in this Article that apply to the importer/disposer and the State of import shall apply mutatis mutandis to the exporter and State of export, by the State of import, or by the States of

import and transit, the requirements of paragraphs 1, 3, 4 and 6 of this Article that apply to the exporter and State of export shall apply mutatis mutandis to the importer or disposer and State of import, or ropby any State of transit.

6. The State of export may allow the generator/exporter to use a general notification where hazardous wastes/other wastes having the same physical and chemical characteristics are shipped regularly to the same disposer via the same customs office of export/import, and in the case of transit, via the same customs office of entry and exit.

7. The States concerned may make their written consent to the use of the general notification referred to in paragraph 6 subject to the supply of certain information, such as the exact quantities or periodical lists of hazardous wastes or other wastes to be shipped.

8. The general notification and written consent referred to in paragraphs 6 and 7 may cover multiple shipments of hazardous wastes/other wastes during a maximum period of 12 months.

9. The Parties shall require that each person who takes charge of a transboundary movement of hazardous wastes/other wastes sign the movement document either upon delivery or receipt of the wastes in question. They also require that the disposer inform both the exporter and the given authority of export of receipt by the disposer of the wastes in question and of the completion of disposal as specified in the notification. If no information is received of export, the given authority or the exporter shall so notify the State of import.

10. The notification and response required by this Article shall be transmitted to the competent authority of the Parties concerned or to such governmental authority as may be appropriate in the case of non-Parties.

11. Any transboundary movement of hazardous wastes or other wastes shall be covered by insurance, bond or other guarantee as may be required by the State of import or any State of transit which is a Party.

International Co-operation

1. The Parties shall co-operate with each other in order to improve and achieve environmentally sound management of hazardous wastes and other wastes.

2. Upon request, make available information, whether on a bilateral or multilateral basis, with a view to promoting the environmentally sound management of hazardous wastes and other wastes, including harmonization of technical standards and practices for the adequate management of hazardous wastes and other wastes, cooperate in monitoring the effects of the management of hazardous wastes on human health and the environment, cooperate, subject to their national laws, regulations and policies, in the development and implementation of new environmentally sound low-waste technologies and the improvement of existing technologies with a view to eliminating, as far as practicable, the generation of hazardous wastes and other wastes and achieving more effective and efficient methods of ensuring their management in an environmentally sound manner, including the study of the economic, social and environmental effects of the adoption of such new or improved technologies, cooperate actively, subject to their national laws, regulations and policies, in the transfer of technology and management systems related to the environmentally sound management of hazardous wastes and other

wastes. They shall also co-operate in developing the technical capacity among Parties, especially those which may need and request technical assistance in this field, cooperate in developing appropriate technical guidelines and/or codes of practice.

3. The Parties shall employ appropriate means to co-operate in order to assist developing countries.

4. Taking into account the needs of developing countries, co-operation between international organizations is encouraged to promote public awareness, the management of hazardous wastes/other wastes and the adoption of new low-waste technologies.

Disposal operations

A. Operations which do not lead to the possibility of resource recovery, recycling, reclamation, direct re-use or alternative uses

D5	Specially engineered landfill, (e.g., placement into lined discrete cells which are capped and isolated from one another and the environment, etc.)
D10	Incineration on land

R3	Recycling/reclamation of organic substances which are not used as solvents
R4	Recycling/reclamation of metals and metal compounds

Information to be provided on notification

1. Reason for waste export

2. Exporter of the waste 1/

3. Generator(s) of the waste and site of generation 1/

4. Disposer of the waste and actual site of disposal 1/

5. Intended carrier(s) of the waste or their agents, if known 1/

6. Country of export of the waste

Competent authority 2/

7. Expected countries of transit

Competent authority 2/

8. Country of import of the waste

Competent authority 2/

9. General or single notification

10. Projected date(s) of shipment(s) and period of time over which waste is to be exported and proposed itinerary (including point of entry and exit)3/

11. Means of transport envisaged (road, rail, sea, air, inland waters)

12. Information relating to insurance 4/

13. Designation and physical description of the waste including Y number and UN number and its composition 5/ and information on any special handling requirements including emergency provisions in case of accidents

14. Type of packaging envisaged (e.g. bulk, drummed, tanker)

15. Estimated quantity in weight/volume 6/

16. Process by which the waste is generated 7/

17. For wastes listed in Annex I, classifications from Annex III: hazardous characteristic, H number, and UN class

18. Method of disposal as per Annex IV

19. Declaration by the generator and exporter that the information is correct

20. Information transmitted (including technical description of the plant) to the exporter or generator from the disposer of the waste upon which the latter has based his assessment that there was no reason to believe that the wastes will not be managed in an environmentally sound manner in accordance with the laws and regulations of the country of import

21. Information concerning the contract between the exporter and disposer.

Notes

The information required on the movement document shall where possible be integrated in one document with that required under transport rules. Where this is not possible the information should complement rather than duplicate that required under the transport rules. The movement document shall carry instructions as to who is to provide information and fill-out any form.

1/ Full name and address, telephone, telex or telefax number and the name, address, telephone, telex or telefax number of the person to be contacted.

2/ Full name and address, telephone, telex or telefax number.

3/ In the case of a general notification covering several shipments, either the expected dates of each shipment or, if this is not known, the expected frequency of the shipments will be required.

4/ Information to be provided on relevant insurance requirements and how they are met by exporter, carrier and disposer.

5/ The nature and the concentration of the most hazardous components, in terms of toxicity and other dangers presented by the waste both in handling and in relation to the proposed disposal method.

6/ In the case of a general notification covering several shipments, both the estimated total quantity and the estimated quantities for each individual shipment will be required.

7/ Insofar as this is necessary to assess the hazard and determine the appropriateness of the proposed disposal operation.

Information to be provided on the movement document

1. Exporter of the waste 1/
2. Generator(s) of the waste and site of generation 1/
3. Disposer of the waste and actual site of disposal 1/
4. Carrier(s) of the waste 1/ or his agent(s)
5. Subject of general or single notification
6. The date the transboundary movement started and date(s) and signature on receipt by each person who takes charge of the waste
7. Means of transport (road, rail, inland waterway, sea, air) including countries of export, transit and import, also point of entry and exit where these have been designated
8. General description of the waste (physical state, proper UN shipping name and class, UN number, Y number and H number as applicable)
9. Information on special handling requirements including emergency provision in case of accidents

10. Type and number of packages

11. Quantity in weight/volume

12. Declaration by the generator or exporter that the information is correct

13. Declaration by the generator or exporter indicating no objection from the competent authorities of all States concerned which are Parties

14. Certification by disposer of receipt at designated disposal facility and indication of method of disposal and of the approximate date of disposal.

Wastes are characterized as hazardous under Article 1, paragraph 1 (a), of this Convention, and their designation on this Annex does not preclude the use of Annex III to demonstrate that a waste is not hazardous.

A1010 Metal wastes and waste consisting of alloys of any of the following:

- Antimony
- Arsenic
- Beryllium
- Cadmium
- Lead
- Mercury
- Selenium
- Tellurium
- Thallium

but excluding such wastes specifically

listed on list B.

A1030 Wastes having as constituents or contaminants any of the following:

- Arsenic; arsenic compounds
- Mercury; mercury compounds
- Thallium; thallium compounds

A1190 Waste metal cables coated or insulated with plastics containing or contaminated with coal tar, PCB, lead, cadmium, other organohalogen compounds or other Annex I constituents to an extent that they exhibit Annex III characteristics.

A2 Wastes containing principally inorganic constituents, which may contain metals and organic materials

A2010 Glass waste from cathode-ray tubes and other activated glasses

A3 Wastes containing principally organic constituents, which may contain metals and inorganic materials

A3070 Waste phenols, phenol compounds including chlorophenol in the form of liquids or sludges

A3180 Wastes, substances and articles containing, consisting of or contaminated with polychlorinated biphenyl (PCB),

polychlorinated terphenyl (PCT),
polychlorinated naphthalene (PCN) or
polybrominated biphenyl (PBB), or any other
polybrominated analogues of these compounds,
at a concentration level of 50 mg/kg or more

A4 Wastes which may contain either inorganic or organic constituents

A4060 Waste oils/water, hydrocarbons/water mixtures, emulsions

(Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal, 2007, pp.1-75)

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