Wallingford, Connecticut Eco-Industrial Park: A Question of Scale
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ABSTRACT
This paper assesses the potential for the development of an eco-industrial park (EIP) along an industrial corridor in a small New England city. We propose present and future linkages among existing businesses and recommend new industries that might be attracted to the Wallingford, Connecticut area to share the inputs and outputs of EIP members. We outline short, middle, and long term strategies for achieving environmental and financial benefits through the application of industrial symbiosis principles.

Five firms from an original list of seven agreed to participate in this project. Representatives from Ametek, Connecticut Steel, Cytec Industries, Resource Recovery, and Ulbrich Specialty Steel Mill were interviewed by our team, and we were afforded a site visit to each operation. Additionally, telephone interviews were conducted with representatives from the Town of Wallingford, local power and water utilities, and Suzio Concrete.

INTRODUCTION
Industrial ecology views industrial systems as part of natural systems and attempts to apply lessons about natural systems to the operation of industrial facilities. The eco-industrial park model offers a primary means to apply these tenets. Through EIPs, industrial ecologists attempt to break down the “once-through” paradigm that characterizes most production processes. EIPs form around a locus of businesses that need not be co-located. They may share energy, water, residues, information, management systems, marketing, or other functions as a basis for achieving greater performance than individually possible.

Wallingford has two key ingredients that make it an ideal candidate for the successful creation of an Eco-Industrial Park: businesses with overlapping inputs and outputs, and attractive business amenities that can induce the siting of additional EIP partner industries. Perhaps as important, however, is the willingness of the existing businesses and Wallingford’s Economic Development Coordinator to work with each another to achieve the potential efficiencies of an EIP arrangement. Despite the favorable climate for new industries, the economies of scale needed by the businesses proposed could be limiting factors in their establishment. Reducing this scale or drawing markets from a larger area will be instrumental in determining the ultimate feasibility of these new ventures.
Finally, the promotion of a virtual EIP and the integration of existing industries into an ecological and aesthetic plan can serve as the central theme for future development in Wallingford. Such a unified vision could rightly be termed a sustainable development plan for Wallingford that would further integrate firms into the natural environment and the community. This vision could establish Wallingford as a national model for sustainable development, differentiate it from other northeastern neighbors, and offer the town a significant competitive advantage over other communities in the future.

Most participants do not join EIPs solely for environmental ends; EIPs and industrial ecology are premised upon the belief that opportunities exist to improve profitability through a systems approach that spurs superior environmental management. In fact, the goals of EIPs are twofold: “to improve economic performance of the participating companies while minimizing their environmental impact” (Lowe and Warren 1996).

The goal is to facilitate materials exchange among existing businesses to reduce costs, increase profitability, and improve environmental performance. At the same time, an EIP project offers an opportunity to spur further economic development, as the remaining residues and demands for further inputs to the manufacturers will suggest other viable businesses that could join the park in order to facilitate closed loop material flows within the EIP.

As part of our investigation, our team reviewed the Plan of Development created by the Town of Wallingford’s Planning and Zoning Commission (POD Update 1993). In this document the Commission stated that its main objective was to “create an atmosphere that is hospitable to encouraging commercial/industrial development in Wallingford.” Specifically, the Commission identified several goals including:

- to develop a town-wide comprehensive infrastructure plan (water, sewer, electric, traffic, etc.);
- to encourage the efficient design/development of buildings and property;
- to encourage further examination of the commercial areas along Route 5 from South Main to Cedar Lane to permit expansion of Route 5 businesses while protecting the integrity of the abutting residential neighborhoods;
- to provide appropriate areas for future commercial and industrial development;
- to expand the use of recycled materials for re-paving of roadways;
- to support the efforts of the utility department in water and energy conservation;
- to support additional water sources to meet future growth.

These focus areas were evaluated in the context of this industrial ecology project and have been incorporated where possible. Considering the time frame (1993) in which the Planning and Zoning Commission developed these
goals, our team believes they are visionary and are consistent with industrial ecology principles. The Commission’s stated goals help to make Wallingford an ideal location for the promotion of EIPs. With further emphasis, industrial ecology and EIPS could serve as the theme for new development in the town. Wallingford could work with the community and businesses to promote itself as a center of sustainable living, integrating its industry into the natural environment and the progressive community.

**SUMMARY OF RECOMMENDATIONS**

The major themes of our team’s recommendations fall into three categories: 1) materials reuse, 2) water reuse, and 3) establishment of an “industrial campground.”

**Materials Reuse**

Several waste streams were found to be logical inputs to existing industrial operations. Where no matches were identified and ample quantities of residues were available, new businesses were proposed. The more significant streams include liquid waste for energy recovery, ash for concrete, scrap metal for processing in a mini-mill, and biological treatment sludge used as fertilizer.

**Water Reuse**

Cytec Industries has a surplus of water that can be used to meet the needs of companies in the area that currently use town water. Our team believes that water requirements of a proposed power station can be met by using the effluent of the town sewage treatment plant in conjunction with a water-use trading program for diversionary users of water from the nearby Quinnipiac River.

**Industrial Campground**

A network of services should be created within the industrial park so that future tenants can set up operations quickly and be responsive when markets evolve. In addition to the typical electrical, potable, and sanitary services, the industrial campground would provide steam, gray water, natural gas, and specialty gases (i.e., argon, hydrogen, and nitrogen).

The time horizons for proposed changes are short-term (one to two years), intermediate-term (three to five years), and long-term (six to ten years). The following is a summary of our team’s recommendations according to the implementation schedule:

**Short-term**

- Exchange high BTU value residues;
- Lay pipes for joint water, natural gas, and industrial gas usage;
- Share transportation of scrap metal;
- Use sanitary sludge as a lawn fertilizer;
- Develop a formal Council on Industry and the Environment.
Intermediate-term

- Site four new businesses in the Wallingford area:
  - ash processor
  - wallboard manufacturer
  - industrial gas manufacturer
  - steel mini-mill
- Use the Council on Industry and the Environment as a vehicle to examine linkages among industries and develop an EIP plan for the area;
- Use wastewater from the Wallingford Publicly Owned Treatment Works (POTW) as cooling water in the planned combined cycle power plant; Develop a water credit trading scheme to mitigate diversions from the Quinnipiac River.

Long-term

- Create a household hazardous waste recovery and recycling program;
- Mine the municipal solid waste landfill for metals;
- Research and implement programs to reduce the volumes of ash, industrial gases, and sludge in process;
- Convert the waste-to-energy plant to a cogeneration plant, selling both steam and electricity;
- Develop an aesthetics code, voluntary environmental initiatives, and shared service functions through the Council on Industry and the Environment;
- Build a canal to carry cooling water through the park;
- Extend planned trails through the area;
- Construct wetlands to treat wastewater.

TOWN OF WALLINGFORD

Situated in Connecticut roughly midway between Hartford and New Haven, Wallingford was founded in 1670 by English Puritans who moved North from New Haven. The industrial revolution eventually changed the character of Wallingford from an agricultural community to a large producer of silver and silverware. Today, Wallingford has grown to a town with over 41,000 people and 1,400 businesses (Malone and MacBroom 1996, Wallingford Economic Development Commission). The ultimate population potential for Wallingford is 52,798 (based upon the zoning map as of 1993 and an occupancy density of 2.6 persons per dwelling) (POD Update 1993). The total acreage of Wallingford is 24,920 acres. The three primary types of land use are residential, commercial and industrial.

The industrial growth in town increased significantly after World War II. The founding companies were Wallace Silversmith, Allegheny Ludlum, Judd Drapery, Ulbrich Steel, Eyelet Specialty, American Cyanimid and Parker Mills. Of these, only Allegheny Ludlum, Ulbrich and Cytec Industries (formerly
Cyanimid) are still in operation. Three additional industrial areas within Wallingford have been developed in the last 35 years.

Wallingford has managed to maintain its industrial base, while many surrounding areas, notably New Haven and Bridgeport, have lost their keystone industries. Significant inducements to businesses have helped the town maintain its industrial keystones while other Connecticut cities have suffered. Wallingford benefits from a central location with excellent access to transportation arteries. Its primary industrial corridor boasts easy on/off from I-91 and Route 15, and sits midway between the east-west arteries of I-95 and I-84. Wallingford also offers access to both passenger and freight rail lines, operated by Amtrak and Conrail respectively (Wallingford Economic Development Commission). These transportation options provide Wallingford businesses easy access to all the major markets in the central and eastern United States. The 500-mile radius surrounding Wallingford includes all cities between Boston, Cleveland, and Washington. Two-thirds of all Canadian consumers residing between Toronto, Ottawa, Montreal, and Quebec also live within the 500-mile reach of Wallingford.

The zoning as of 1993 (latest available data) designated 3,935 acres for industrial use. Of this amount approximately 25% is estimated to be vacant. Of the parcels that are developed, fewer than 20% are covered with buildings. These figures indicate that there is ample space available for additional industrial growth. An additional 150 acres are slated for industrial development by 2010 (Milone and MacBreen 1996).

Wallingford has three municipally owned and operated utilities – electric, water, and sewer. The electric operation was created in 1899 as Borough Electric. Today, as it owns and services all of the distribution system in Wallingford and North Branford, the Town has negotiated directly for wholesale electricity rates on behalf of the entire community. As a result, area businesses pay some of the least expensive rates for power in New England (Wallingford Economic Development Commission). Wallingford is one of six municipalities that have been exempted from participating in the deregulation of power.

The electrical utility also owns a small power generating plant, the Alfred Pierce Station, which operates infrequently for peaking purposes by burning oil. There are plans to construct a 540-megawatt combined cycle power station. This plant will be owned and operated by Pennsylvania Power and Light Company and may be sited on the Pierce property.

The water utility maintains four reservoirs and three wells to supply water to customers. Three of the reservoirs are channeled to Pistapaug Pond, where water is drawn out and treated. A new water treatment plant, with a maximum capacity of 12 million gallons per day (MGD), was built in the early 1990s. The average quantity of water treated is 5 MGD, of which 37%, or 1.85 MGD, is provided to industrial users. The industrial potable water use is projected to increase to 2.12 MGD by 2010 (Malone and MacBroom 1996).
The sewer utility completed an eight-MGD treatment facility in 1989. This is an advanced secondary treatment plant that uses rotating biological disks followed by secondary settling, post aeration and ultraviolet disinfection (POD Update 1993). The average flows are currently 6 MGD (E. Kruger, personal communication).

EXISTING FACILITIES
Initially, seven Wallingford businesses were approached to participate in the project. While two declined, citing proprietary concerns and time constraints, five participated. Two other facilities, Suzio Concrete and the Pennsylvania Power and Light Company electric plant (proposed for development by the Town of Wallingford), were contacted as potential future partners. All five of the initial firms are located in close proximity to each other and enthusiastically embraced the opportunity to share materials.

Company Overviews

Ametek Specialty Metals
Ametek Specialty Metals produces unusual drawn wire, rolled strip metal, and shaped components from specialty metal powders that are manipulated under high-temperature conditions (see Appendix B for complete materials inventory). Nearly all off-specification metal or scrap is recycled locally or returned to Ametek’s parent company for reprocessing. The facility receives frequent shipments of hydrogen and liquid nitrogen, which it injects into the production processes to maintain a stable, non-oxidizing atmosphere. Minimal amounts of water are drawn from the city on a daily basis as make-up water and only
minute quantities are discharged to a Publicly Owned Treatment Work (POTW) via truck. Ametek would like to expand, but is spatially constrained by wetlands. The plant also seeks users for off-specification, high-carbon, pure iron powder, and iron aluminide powdered alloy.

**Connecticut Steel**

Connecticut Steel rolls plain carbon steel billets into wire coils and rebar for concrete reinforcement. The facility employs large quantities of electricity and natural gas, and obtains irregular, though sometimes large, quantities of water from the city. Connecticut Steel’s primary residues are a wet, iron oxide, known as mill scale, and scrap steel. The company pays for the removal of the mill scale and sells its steel to a Waterbury dealer (see Appendix B for details of all residues).

![Figure 2 Connecticut Steel](image)

**Cytec Industries Incorporated**

Cytec Industries is itself an industrial park of sorts, comprised of three businesses: Cytec Industries (resins), A.C. Molding (thermoset molding compounds), and Cyro Industries (thermoplastic molding compounds). Many of the processes combine organic chemicals to produce molding compounds or resins. In addition to these chemicals (detailed in Appendix C), the park employs steam and large quantities of energy. Because a high humidity environment ruins one of its products, Cytec must dehumidify its largest building. As an indirect result, the facility employs large quantities of non-contact, non-toxic cooling water on a daily basis. The majority of this water is drawn from deep wells and most is eventually discharged into the Quinnipiac River, which abuts the company’s property. In addition to non-contact cooling water, Cytec
also uses a substantial quantity of water within its manufacturing processes. An onsite industrial wastewater treatment plant is maintained to process the water biologically, resulting in large volumes of sludge. Cytec has roughly 100 acres of undeveloped land available on its property and would consider proposals for further development of the land.

Resource Recovery Facility
Resource Recovery Facility is an 11-megawatt power plant fueled by municipal solid waste, or trash. In addition to operation and maintenance-related wastes, the mass burn waste-to-energy facility also produces 42,000 tons of mixed ash annually (see Appendix D). Nearly 230,000 gallons of water are used daily, drawn from city water to make up for evaporated cooling water.
Ulbrich Stainless Steel

Ulbrich Stainless Steel re-rolls steel and titanium under high temperatures to create rolls of particular thickness and quality. Like Ametek, Ulbrich consumes large quantities of industrial gases, including argon (See Appendix E). Since the firm’s metal wastes are recycled largely by local handlers, chemical residues with high-BTU value and sand contaminated with oil comprise the bulk of the firm’s wastes. Ulbrich requires only small quantities of make-up water.
Previous Interaction Among Clients
Wallingford area businesses do not have a strong history of interaction with one another. Project clients cited only three examples of loose interactions that have previously occurred. Cytec Industries once received its steam from the adjacent Resource Recovery Facility. While the pipe between the facilities remains intact along the Route 5 right-of-way, Resource Recovery discontinued service a few years ago, as it became more economic to optimize output for the sale of electricity. There are currently no plans to renew this relationship, and Cytec currently fulfills all of its steam needs with its own natural gas-fired boilers. Some of the area businesses have conceived a plan to jointly fund a natural gas spur pipeline to deliver fuel at prices below those offered presently by utilizing the Yankee Gas pipeline. The businesses hope that any EIP project might help them to facilitate the relationship necessary to support this gas project. Finally, some personnel among area businesses belong to and attend meetings of the same engineering society, and some are members of the local emergency planning committee (LEPC).

TARGET ISSUES
In the next section, different scenarios for the Wallingford EIP will be discussed, beginning with a short-term (one to three year) scenario, moving through a three-to-five-year scenario, and finishing with a long-term plan (five to ten years and beyond). The major themes of these scenarios are highlighted below and address metals flows, water supply, ash reuse, and the creation of an industrial campground.

Materials Reuse: Metals and Ash
There are two remarkably large residue streams emitted from our facilities of interest. The largest is scrap metal. Three of the five industries that were studied manufacture steel products. Scrap from cutting and trimming the raw material while being processed results in an annual production of 18 million pounds of scrap metal. Currently, individual facilities are trucking the scrap metal off site for eventual recycling.

The largest output stream of the Resource Recovery Facility is ash. The ash is a mixture of two residue streams: bottom ash, left in the incinerator as the trash burns, and fly ash, produced from air filtration devices as hot gases leave the plant. Currently the plant is paying for the removal and eventual landfilling of the 42,000 tons produced yearly.

As research over the past two decades has shown, there are many viable uses for ash as a product. Because it exhibits the same engineering properties as sands, gravel, and clays, bottom ash performs well as an aggregate in cement, concrete, and asphalt (ASH 1989).
hazardous sulfuric acids. Calcium sulfate is also known as industrial gypsum, and so fly ash has been marketed as a substitute for gypsum in wallboard manufacturing (Ehrenfeld and Gertler 1997).

There are several constraints on the Resource Recovery Facility’s potential to turn its ash from residue to product. The Supreme Court’s 1994 interpretation of the Resource Conservation and Recovery Act (RCRA) requires facilities to test their municipal waste combustion ash as a potential characteristically hazardous waste. Companies around the country completed this testing, and found the bulk of ash safe for reuse (ASH 1996). While the Resource Recovery Facility will be legally required to test its own material, our team assumes that it will pass federal regulatory scrutiny as well.

The Connecticut Department of Environmental Protection’s (DEP) requirements are a bit more problematic. Thus far the DEP has prevented the reuse of ash as aggregate due to end-of-life concerns. When construction or road materials are no longer in productive use, they are demolished, and either landfilled or reused. Tiny, breathable dust particles are swept into the atmosphere when the materials are demolished. The DEP is concerned that this uncontrollable dust, rich with heavy metals and dioxins, will be hazardous to human health (L. Hewett, personal communication). Strict labeling, planning, and recovery requirements may mitigate this concern. Ideally, the material would never be crumbled and sent to a landfill; instead, it would always be reused in another product. As long as the DEP is able to track this material throughout its life, it could be used in applications where any toxicity concern would not be a problem. This area is one that Connecticut’s ash producers will have to work with the state government to resolve. While these concerns prevent current recycling efforts, our team’s suggestions are based on the premise that these problems will be overcome.

Water Resources
Not surprisingly, all of the facilities surveyed use water for their operations. Uses vary from once-through non-contact cooling water to water consumed as an ingredient in industrial processes. All of the facilities except Cytec Industries receive water exclusively from the municipality. Cytec receives some water from the Town, but the majority comes from on-site wells and from the Quinnipiac River (see Figure 6).

Cytec has two primary discharges of water. Non-contact cooling water is discharged to the storm sewer and then flows to the Quinnipiac River. This combined flow represents on average 1 MGD. Cytec also operates an industrial wastewater treatment plant that discharges approximately 3.5 MGD directly to the Quinnipiac River. The entire 4.5 MGD from Cytec has the potential for being re-routed to the other companies in the Wallingford industrial area.

The planned new power station has a significant requirement for cooling water. The Pennsylvania Power and Light Company estimates it will need approximately 3 MGD to replace water that is evaporated from the power
generation process and boiler blowdown. The project planners requested the use 3 MGD of the 6 MGD effluent from the Wallingford POTW, which is located only 500 feet from the proposed site of the power station. The DEP was not averse to the use of sanitary effluent for the power station, but they did not want to set the precedent of diverting water that would normally flow to the Quinnipiac River. The Quinnipiac River has low-flow conditions during some periods of the year; the DEP is concerned that diversion would further reduce the flow. Furthermore, setting a precedent for diverting flow from the Quinnipiac River may open the door for others to do the same. Therefore, our team has assessed not only water use, but also its impact on the flow of the Quinnipiac River.
The proposed power station is now tentatively planning to have its water demand supplied by a three mile pipeline from North Haven to Wallingford. The origin of this water is from non-drinking water wells that communicate with tidal reaches.

**Industrial Campground**

Trailer campgrounds are created to provide ultimate flexibility and ease of use to the customer. Campers can pull their recreational vehicles (RVs) into allotted sites and have all necessary services within reach, typically an electricity source, potable water and a sewage drain. Some even have a cable TV line.

Our team proposes the establishment of an “industrial campground” in Wallingford. This would involve identifying land in the target area for development with services that would be appropriate for medium to heavy industrial activity. The same services available at recreational campgrounds would be provided, such as electricity, potable water, and sewer. Additionally, gray water, steam, and specialty gases would be readily available.

Although the manufacturing facility of the future is unknown, there is a trend toward flexibility. Companies have to be quick to adjust to new trends in manufacturing processes as well as the desires of consumers, which can also move swiftly. Under these conditions, an industrial campground with pre-established services could allow existing firms to change processes with minimal delay, and could accommodate new businesses quickly.

This concept would not be limited only to services. Modular buildings would also be part of the planned industrial campground. These modular buildings would be configured for the incoming tenant, and reconfigured for successive tenants. Just as a single manufacturing facility may contain several products and product lines, the industrial campground could accommodate several companies within a single building. Walls within the shop area and office areas would be mobile to fit the needs of the client company.

By breaking down the paradigm of “one business, one building” and establishing a structure where businesses can be co-located under one roof, there can be a sharing of material inputs and outputs, and strategic purchasing for increasing the economies of scale. The sections that follow will be developed in concert with this concept of an industrial campground.

**SHORT-TERM SCENARIO: ONE TO THREE YEARS**

Our proposed plan for the Wallingford EIP has been broken into three time frames. The first section focuses on modifications that are achievable within one to three years. Rather than confine the discussion only to ideas known to be economically viable, all suggestions have been included in the hopes of stimulating further thinking and perhaps overcoming barriers in creative ways. The difficulties of implementing these changes will be discussed in depth later.

For the near future, we suggest that the Wallingford EIP businesses take the following steps:
• Exchange high BTU value residues;
• Lay pipes for joint water, natural and industrial gas usage;
• Share transportation of scrap metal;
• Use sanitary sludge as a lawn fertilizer;
• Develop a formal Council on Industry and the Environment.

High BTU Value Resources
One of the prime materials identified for exchanges between facilities was the high BTU value residues produced by Ametek and Cytec. These materials, primarily comprised of oils and solvents, total 73,000 gallons each year and are currently sent off site for energy recovery. The Resource Recovery Facility uses
130,000 gallons of diesel fuel annually when it starts and stops the plant for maintenance checks. The recovery of the high BTU value residues in place of diesel fuel is proposed (see Appendix H). This exchange would reduce transportation costs and associated environmental harms, and begin the integration of the businesses into an EIP.

**Industrial Gases**

Four of the five businesses in the project have been identified as large users of industrial gases. While the Resource Recovery Facility does not use natural gas, it is the primary internal energy source for each of the others. Discussions have already commenced regarding the potential to install a natural gas pipeline that would service three of the plants—Cytec, Ametek, and Ulbrich. This transmission would be cheaper than comparable quantities purchased independently. Connecticut Steel is also a large user of natural gas, but due to the volume used has already worked out an efficient arrangement.

With the installation of a natural gas pipeline comes the opportunity to install several additional pipelines, at lower environmental and economic costs than if installed separately. Among these pipelines would be one or more designated for specialty gases, including argon, hydrogen, and nitrogen. Ametek, Cytec, and Ulbrich currently consume one or more of these gases in their production processes. The use of the pipelines will be discussed in the intermediate-term scenario. Laying the pipes will further the conversion of the site to an industrial campground—an area ready-made for industry. The additional infrastructure also supports goals expressed by the Town Planning and Zoning Commission and, due to the homogeneity of the area, would not impact any residential areas (POD Update 1993).

**Metals**

Scrap metal is an important residue produced by the steel industries in the Wallingford area. Three industries, Ametek, Connecticut Steel, and Ulbrich, produce mill-generated scrap. The scrap, produced as raw steel, results from the cropping and shearing of metal plates while they pass from one process to another (Hogan 1998). Combined, these industries have an annual scrap metal output of 18 million pounds. Scrap metal is valuable and a large market exists for businesses whose only function is to recycle scrap metal.

Currently, there are no metal recycling facilities within Wallingford. Each industry is paying an outside company to remove and transport its scrap. Ametek ships its steel powders to its parent company in Pittsburgh. Ulbrich ships residue steel to the scrap yard in North Haven, and Connecticut Steel has its metal residues picked up by a scrap dealer in Waterbury. Sharing transportation is one way for Wallingford’s metal industries to achieve cost savings in scrap metal removal.

The Wallingford area metal businesses could reduce their respective investments in excess inventory by integrating their shipments of scrap metal. By increasing the number and therefore the frequency of shipments, each can...
reduce its total quantity of metal in process. This may result in less space required for waste storage, freeing up valuable room on the shop floor. Both improvements could increase the cost effectiveness of managing work in progress inventory.

An even better situation would be to have the industries contract with a scrap metal dealer in Connecticut. There are over 70 scrap metal dealers within the state. In addition to cost savings, sharing transportation would benefit the environment through reduced pollutant emissions and less traffic on highways.

**Sludge**

A large residue stream from Cytec is sludge produced from the onsite wastewater treatment system. The sludge is incinerated onsite, using approximately 280,000 gallons of #2 fuel in the process. Due to the high concentrations of nitrogen, phosphorus, and potassium typically found in sludge from biological treatment processes, companies have found productive use for the material as a fertilizer (Manahan 1994). Given understandable concern over chemical constituents and public perception, Cytec has expressed a preference that the material be used for non-food purposes. For the near future, the most logical use of the sludge is as a fertilizer for the grounds around the EIP.

Beyond immediate EIP needs, the sludge could be used by the Town of Wallingford for municipal fertilizer needs. The Town has expressed a desire for recycled materials in repaved roadways. This interest in recycled materials could extend to using residual sludge as fertilizer along roadways, tree lawns, and parks (POD Update 1993). Additionally, Cytec may do well to market their sludge to local non-food agribusinesses. The material is well suited for fertilizing trees, flowers, or other ornamental plants. Other viable uses are as fertilizer for golf courses or as sodded landfill cover (see Figure 7). Should no suitable agribusinesses be present, the sludge could form the basis for a new company in the area.

**The Wallingford Council on Industry and the Environment**

It is rumored that the success of the EIP in Kalundborg, Denmark, is partially attributable to the plant managers’ involvement in the local Rotary Club. The Club provided an opportunity for casual talk about their companies, and linkages developed from these conversations. In Wallingford, several of the plant managers meet through the local emergency planning committee; still others visit at the engineering society meetings. Our team recommends the development of a formal Council on Industry and the Environment to further communication among the industries.

Lowe et al. (1997) cite the existence of a formal organizing structure as crucial to the development of an EIP. The Wallingford Council would be comprised of leaders from each industrial facility, in addition to municipal representatives and residents. Alongside several environmental goals, the Town of Wallingford identified the further expansion and development of industry as a key goal in its 1993 Plan of Development (POD Update 1993).
Participation on the Council will allow the municipality to direct and encourage the industrial development in coordination with its stated goals. By bringing all stakeholders together in one place, the Council will include many points of view as it develops a vision for the area. Initially the Council may serve as a forum for discussion of ongoing issues—the installation of a natural gas pipeline, or the use of water and wastewater in the area. As the companies develop greater trust and openness through the regular meetings of the Council, more issues can be tackled.

**Water Resources**

Using Cytec’s wastewater streams, the immediate water needs of several nearby industries can be met (see Figure 6). Ametek, Connecticut Steel, and the Resource Recovery Facility can be supplied 220 gallons per day (GPD), 136,000 GPD and 250,000 GPD, respectively. It is proposed that pipelines be laid between Cytec and Connecticut Steel with a connection added for Ametek. For the Resource Recovery Facility, it may be feasible to pump the water through the steam pipe that was installed several years ago to supply steam from Resource Recovery to Cytec. By using the non-contact cooling water that Cytec generates, no water quality concerns should arise from this arrangement.

Our team believes this scenario represents a logical first step for the Wallingford EIP. The recommendations do not involve large investments of capital that have not already been explored by the partner companies. Instead, the scenario centers on taking a first step: building trust and openness to the idea of an EIP by meeting immediate needs. A successful first step will pave the way for more complex interactions in the future.

**INTERMEDIATE SCENARIO: THREE TO FIVE YEARS**

The focus of the intermediate-term scenario is the expansion of the Wallingford EIP to draw new businesses into the area. All of the recommended economic developments are connected to the current businesses via one or more material exchanges. An ash processor, wallboard manufacturer, and mini-mill all utilize residues from ongoing processes as raw inputs to their products. Other new businesses could produce the materials that could be used as raw inputs for current facilities: an industrial gas manufacturer would produce argon, hydrogen, and nitrogen to be used by Ametek and Ulbrich. The ideal new business is one that will use current residues to produce materials that can be used as inputs to another facility. An ash processor, using the Resource Recovery Facility’s ash to make aggregate for Suzio Concrete, meets this requirement, as does a mini-mill. Developing these industries in the area will reduce transportation costs and integrate the facilities. While focusing on economic development, other suggestions regarding the role of the Council on Industry and the Environment and the use of water resources are also included. In the following three to five years, we recommend:
• Siting four new businesses in the Wallingford area:
  • an ash processor,
  • a wallboard manufacturer,
  • an industrial gas manufacturer, and
  • a mini-mill
• Using the Council on Industry and the Environment as a vehicle to examine linkages among industries and develop an EIP plan for the area;
• Using wastewater from the Wallingford POTW as cooling water in the planned combined cycle power plant;
• Developing a water credit trading scheme to mitigate diversions from the Quinnipiac River.

Ash
If the regulatory constraints on ash reuse can be overcome, the Resource Recovery Facility can control other potential problems in ash reuse. The characteristics and quality of the ash is one such issue. The current stream is a mixture of two residue types. Fly ash and bottom ash contribute different characteristics to the ultimate residue: bottom ash is a mixture of unburned hydrocarbons with chunks of metals and glass, while fly ash is predominantly heavy metals, calcium sulfate, unreacted lime, and particulate matter. If separated, the two streams would be purer in their characteristics, and consequently it may be easier to find markets for each.

Once separated, the streams may need to be purified further. Ash is often sieved to remove large objects and produce a finer product of similar size (ASH 1989). The two streams also contain large quantities of water, typically 25-30% by weight (ASH 1989). The water contributes to the weight, increasing hauling expenses, and creating a less desirable aggregate. Reducing the water content through drying would decrease hauling costs and increase marketability. Finally, the bottom ash should be processed to reduce metal content. Both ferrous and nonferrous metals are present, and if recovered, could provide an additional market product, while improving the purity of bottom ash for resale.

The ultimate goal of these two processes is to make the residue stream more viable as market products. While it would be possible to undertake the processes within the Resource Recovery Facility, it is also conceivable that a third party could process the ash for resale. In fact, the desire to purchase bottom ash through a processor for aggregate has been expressed by Suzio Concrete, although it indicated that it would need a separate storage silo for this material (see Figure 8). The intermediate ash processor would be another form of economic development in the Wallingford area.

The Resource Recovery Facility would benefit from reduced transportation and hauling costs, while Suzio would benefit from a local, reliable source of aggregate, and the Town of Wallingford would benefit from an increased tax base and more jobs. In addition to these economic benefits, the Town of
Wallingford would meet its goal of increasing the use of recycled materials by specifying the use of concrete with ash for future infrastructure needs (POD Update 1993). While the economic details of the proposed scenario are beyond the scope of this project, the potential benefits merit further consideration.

A second type of facility could be brought in to deal with Resource Recovery Facility’s fly ash residue. In Kalundborg, Denmark, a wallboard manufacturer replaced virgin gypsum with fly ash—primarily calcium sulfate, or industrial gypsum—from the local coal-fired power plant (Ehrenfeld and Gertler 1997). This seems a viable option for the Resource Recovery Facility’s fly ash as well. Should a wallboard manufacturer want the material processed before use in manufacturing, the ash processor described above could handle this task.
Industrial Gases
The specialty gas pipeline recommended previously will come into use during this intermediate time frame. We recommend the siting of an industrial gas manufacturer in Wallingford as one of the new economic developments (see Figure 9). Ametek uses a combined total of 108 million cubic feet of hydrogen and nitrogen each year, while Ulbrich consumes argon, hydrogen, and nitrogen at a rate of 1.4 billion cubic feet per year. Cytec also uses some nitrogen, albeit at a lower rate than the other two. These gases are consumed as they are used to create a reducing environment to prevent oxidation of the metal surface during manufacture (Air Products 1999). Thus an industrial gas manufacturer could supply argon, nitrogen, and hydrogen to Ametek, Ulbrich, and Cytec via the pipelines. Filtering and purifying air readily withdraws pure argon, nitrogen, and oxygen (Universal Industrial Gases 1999).

Hydrogen, made through the catalytic conversion of steam and methane, could also be produced (Air Products 1999). With the siting of a gas manufacturing plant within the industrial park, the three companies would be freed from the costs of transporting and storing gases; instead, they could rely on the fresh, instantly delivered materials from the new manufacturer. This material would be distributed via a network of pipelines (as discussed in the industrial campground concept).

Metals
As described in the short-term scenario section, scrap metal is currently being carried off site for recycling. Although sharing transportation costs of scrap metal removal provides a good short-term solution to cost reduction, the establishment of a mini-mill within Wallingford may prove to be even more economically beneficial. Mini-mills began to appear across the US after WWII, when plants shifted from open hearths to electric furnaces. Since then, this industry has rapidly expanded; there are over 50 mini-mills in the US operated by more than 31 companies (Hogan 1988).

There are several basic characteristics of a mini-mill. Originally, a mini-mill was considered to have 100,000 tons or less of raw steel capacity, while today some plants have a steel making capacity well over 1 million tons (Hogan 1988). The equipment consists of an electric furnace wholly dependent on scrap, a breakdown mill to reduce small ingots to billet size or a continuous caster that casts billets directly from molten steel, and a bar mill. The product line is usually restricted to concrete reinforcing bars, merchant bars, and in some cases, light structural shapes, such as small angles and channels. The original mills served a market usually within a 200- to 300-mile radius of the mill (Hogan 1988).

The operation and integration of a mini-mill within the EIP would be relatively simple. The raw material for the mill would be the scrap metal generated by the three steel industries (see Figure 9). The scrap metal would be melted by an electric furnace and refined into steel. The molten steel is poured into a ladle and discharged into a continuous caster. Most mini-mills cast billets that are reheated and rolled into final products on the bar mill.
The establishment of a mini-mill for scrap metal would substantially reduce transportation costs. Rather than trucking the scrap through three states, it could readily be delivered locally. In addition to reducing transportation costs, cost savings on raw materials would also result. Reprocessed metals could be used to supplement raw materials, thereby reducing the amount of virgin raw materials needed. The use of reprocessed metals in the manufacturing of products closes the loop for metal flows. All metal scrap is reused, preventing the need for disposal into a landfill. The scrap metal produced by the manufacturing process would be taken to the mini-mill, processed, and sent back to the factories to be used again in manufacturing.

Figure 9  Current and Proposed Industrial Residue Flows II
The Wallingford Council on Industry and the Environment

In the intermediate-term scenario, the Wallingford Council on Industry and the Environment would play a leading role in the development of an EIP. Joint work on a natural gas pipeline and wastewater reuse could give way to more specific discussions of materials inflows and outflows. We were unable to identify a large number of residue exchanges between existing companies for several reasons. One primary reason was a concern over proprietary matters. As the companies work together through the Council and further understand the concept of an EIP, these proprietary concerns may be lessened. Another reason we were not able to find more linkages may have been the number of extremely similar companies – three of the five entities conduct metal reforming operations. These processes use similar materials, reducing the opportunity for unique exchanges among them. With the development of a Council, more industries will be involved, and a greater variety of materials will be available for exchanges.

In addition to examining the linkages between current industries, the Council is an ideal place to develop and implement a more holistic EIP plan for the area. For instance, the Council could recommend the types of industries it would like to see drawn to the Wallingford area, basing its recommendations on the material flows and resources already present. It could also suggest facility requirements; for example, new plants should exhibit a set level of energy efficiency, introduce no new consumptive uses of water, be located on brownfields, and demonstrate two or more links to current industries in the area. This type of development would take more care in implementation. Actual regulations would go beyond the scope of the Council, but simply having a group of people consciously focused on environmental issues could do much to pressure other industries to meet their suggestions, regardless of legal requirements. In this manner the Council provides an excellent forum for further developing the Wallingford EIP.

Water Resources

As the planned Pennsylvania Light and Power Company plant comes online during this intermediate time frame, our team proposes that its water needs be met by the effluent of the Wallingford POTW. The extensive use of the waste treatment plant effluent is consistent with Wallingford’s goal of water conservation (POD Update 1993).

The use of this water would prevent the need for a pipeline to be installed from North Haven. Although diversion from the Quinnipiac River is still an issue, our team proposes a trading scheme to decrease the diversionary flows from the river. Anyone currently drawing water from the river would be given permits or credits for the amount of water that is not returned. The power station would be required to replace the water that it receives from the POTW with credits purchased from users within the watershed.
This recommendation is made on the assumption that it would be less expensive for other water users to reduce their consumption than to construct a three-mile pipeline. A trading scheme would also allow reusing water supplies instead of developing a virgin source. A full financial analysis will need to be conducted to determine if this assumption is correct.

The three-to-five year recommendations build upon steps suggested in the short-term scenario. Adding several new businesses will close the loop for particular materials, by processing the residue from one company to create input material for another. Perhaps it is unrealistic to assume these facilities will be sited and online within five years. The cost and scale of economy for particular issues also may make some recommendations impractical. By creating an ideal case scenario, creative thinking around these issues may be stimulated.

LONG-TERM SCENARIO: FIVE TO TEN YEARS
The final scenario proposed for the Wallingford EIP is more theoretical than the previous sections: if there were no restrictions, what are the preferred results? Our recommendations focus on three themes: researching methods to reduce the toxicity and volume of residue material, improving the appearance of the EIP, and integrating nature. These last two themes are interconnected: our recommendations highlight land uses that will enhance the visual appeal of the park while concurrently performing needed industrial functions and providing desirable social functions and wildlife habitat.

The final piece of this puzzle is the development of an industrial campground. This feature of the EIP will attract small and medium sized businesses that require short lead times for start up and extreme flexibility in their manufacturing processes.

In the next five to ten years, our team recommends that the Wallingford industrial park:

• Create a household hazardous waste recovery and recycling program;
• Mine the municipal solid waste landfill for metals;
• Research and implement programs to reduce the volumes of ash, industrial gases, and sludge in process;
• Convert the waste-to-energy plant to a cogeneration plant, selling both steam and electricity;
• Develop an aesthetics code, voluntary environmental initiatives, and shared service functions through the Council on Industry and the Environment;
• Build a canal to carry cooling water through the park;
• Extend planned trails through the area;
• Construct wetlands to treat wastewater.
Ash
In the long term, the Resource Recovery Facility should look at new ways of producing ash. There are two areas to be researched: first, methods to decrease hazardous characteristics of ash, and secondly, methods to decrease the volume of ash generated. The hazardous characteristics—high heavy metals and dioxin content in a readily breathable form—are the basis for the Connecticut DEP's concerns regarding reuse of fly and bottom ash. The initial separation, processing, and labeling steps recommended above may do much to combat these fears. Taking these steps further, the facility could control the types of materials burned.

Municipal solid waste typically does not contain many hazardous constituents, making it feasible to separate out the ones that are. One way to do this would be to implement an aggressive recycling program: the Resource Recovery Facility could serve as the momentum behind a household hazardous waste recovery plan. Such a program could target batteries, old aerosol and paint cans, and other items typically found in household waste, for appropriate reuse or disposal.

In addition to improving the quality of ash produced, a recycling program would educate local residents on environmental issues, strengthen the relationship between the city and the facility, and, of course, offer substantial environmental benefits by way of reduced materials use. Recycling programs may also present another opportunity for an entrepreneur to open a viable recycling business. Battery recycling could, for example, be extended to area businesses so as to gather the throughput necessary to support such an endeavor.

Along with decreasing the toxicity of the ash, the Resource Recovery Facility should look at ways to reduce the volume of ash generated. While these recommendations may make ash production viable as a market function, the ultimate truth is that ash is a byproduct: electricity is the facility’s focus product. Any incineration methods that would reduce the ash generated would presumably recover more energy from the trash itself. The Energy Answers Corporation (EAC) has greatly increased energy recovery from solid waste by shredding the trash and then burning it in midair. Shredding improves the uniformity of the fuel, while midair incineration increases the surface area available for air-fuel contact, creating a thorough burn. Typical mass burn plants produce an ash that still contains 8% combustible material. The EAC’s plant in Rochester, Massachusetts produces an ash containing less than 1.5% combustible material (EAC 1999). These methods need to be investigated more fully for their applicability to the Resource Recovery Facility. Given that they may need capital investments to complete, they are included in the Wallingford EIP’s long-term scenario.

*In addition to improving the quality of ash produced, a recycling program would educate local residents on environmental issues, strengthen the relationship between the city and the facility, and, of course, offer substantial environmental benefits by way of reduced materials use.*
Industrial Gases
In the long run, our team recommends that all companies take a hard look at how they are using industrial gases. Are these methods necessary? Producing argon and nitrogen is a cryogenic process, demanding large amounts of energy to maintain cool temperatures (Universal Industrial Gases 1999). The steam/methane reforming to obtain hydrogen also requires much energy to induce the high temperatures necessary for catalytic conversion (Air Products 1999). The companies could reduce their embedded energy budgets by reducing gas consumption. Could new methods be developed that do not require consumptive uses of gases? While the current procedures may be state of the art, technology is ever evolving. We recommend that decreasing the use of specialty gases remains high on the list of research and development topics.

Metal Recovery from the Landfill
Across the street from the Resource Recovery Facility, a municipal solid waste landfill is located within the bounds of the Wallingford EIP (see Figure 10). The concentration of metals in Municipal Solid Waste (MSW) is such that it is economically feasible to mine them for use (National Research Council 1987). With the siting of a metals processing facility in the Wallingford EIP, this may be an opportunity to process scavenged metals from the landfill.

As the MSW is mined from the landfill, the non-metallic portion can be transported to the Resource Recovery Facility and burned for its energy content. Once the metal is processed, this additional source of raw material can be offered to the many firms in the park and in the region that produce metal products.
Steam
The typical power plant is a highly energy inefficient process, commonly achieving only 30% efficiency (Graedel et al. 1998). Cogeneration is one way to greatly increase energy efficiency while simultaneously producing two marketable products: steam and electricity. Currently the Resource Recovery Facility produces electricity by incinerating trash. The heat from the fire converts water to steam, and the steam rotates a turbine, generating electricity. From there the steam is condensed via non-contact cooling water. The condensation process is one source of inefficiency in the process. A cogeneration plant eliminates this issue by intercepting the steam just after contact with the turbine. Rather than cool and condense it, the energy-rich steam is redirected to another user. Both steam and electricity are produced, and the overall energy efficiency of the plant increases to 80% (Graedel et al. 1998). Cooling water is no longer needed, though the increased use of water for steam may balance this reduced use.

In the past the Resource Recovery Facility has sold steam to Cytec, but ended this practice when the production of electricity became more viable. With the conversion to a cogeneration plant, the facility can sell both electricity and steam (see Figure 10). The 45,000 pounds per hour that Resource Recovery can produce will be a substantial portion of the 130,000 pounds per hour needed by Cytec.

Sludge
In the long term, Cytec should look at ways of reducing and refining sludge production. As a byproduct, it currently has only limited uses. Improving the quality of the sludge would greatly enhance its marketability and thus the range of options for reuse. The volume of sludge generated should be targeted for reduction. A lower volume of improved quality sludge can only mean increased efficiency in the wastewater treatment process, which is the ultimate goal.

The Wallingford Council on Industry and the Environment
In the long term, the Wallingford Council on Industry and the Environment would take a proactive role in local environmental issues. One of these issues would be aesthetic concerns. Currently the area is a mix of older manufacturing plants. A mutually agreed upon aesthetics code could recommend that all facilities develop indigenous plantings in open spaces facing public areas. Rooftop plantings hide an unpleasant roof while simultaneously reducing heating and cooling costs. Reduction of impervious surface can decrease potentially problematic runoff. Simple yet useful guidelines such as these could be the basis of a code focused on improving the area’s aesthetic qualities.

In addition to tackling aesthetic concerns, the Council could develop agreements or competitions among industries. For instance, all industries could aim to reduce their energy consumption by 10% over a three-year period. Or the Council might offer an award to companies that use only renewable energy sources. Just as the U.S. EPA has developed a number of voluntary industry-government partnerships that increase productivity while benefiting
the environment, the Council could be a local forum to do the same (EPA 1999).

Finally, the Council could complete the progress of an EIP by developing shared independent functions between entities. Such collective functions—such as a single parking lot, a carpool system, or joint regulatory compliance permits—would reduce the cost of each company providing their own, while further integrating the businesses. The reduction of costs affords each company the opportunity to increase the quality of service offered while concurrently increasing the scope of available resources. The trust and cooperation necessary to complete these joint functions should be in place at this later point in time. By moving from immediate concerns to more long-range functions, the Wallingford Council on Industry and the Environment could provide a forum for communication and visioning.

**Water Resources**

To further address aesthetics and water reuse issues, we recommend the construction of a watercourse that winds its way throughout the industrial area. This canal would eventually take all of the excess water from Cytec (including its effluent from the industrial waste treatment plant) and excess water from the Wallingford POTW. The canal would not only provide for scenic vistas within a rather bleak industrial area, but it would also provide a means of water conveyance to other parts of the industrial park. The canal would be of sufficient size to allow rapid dispersion of heat from cooling water, so that one company could discharge water to the course, and another could withdraw it shortly afterward. This scenic waterway could provide additional habitat for area wildlife and, as described below, could be lined with walkways or trails. Excess water flows and groundwater seepage would be directed to the Quinnipiac River.

In addition, we propose that trails be installed that follow the cooling water waterway. A linear trail has been planned alongside the Quinnipiac River. A primary goal of the project is to enhance the aesthetic appreciation of the Quinnipiac River valley. The trail is proposed to extend the entire north-south distance of the Town of Wallingford and eventually connect to an existing trail in Cheshire and a proposed trail in Meriden. Although most of the trail is located on the west side of the Quinnipiac River, the trail crosses over to the east side just before it meets the southern border of town. This places the trail within the Wallingford industrial area.

Linking the planned Quinnipiac trail to the EIP watercourse would provide additional trails for the community and bolster the campus feel of the industrial area. Employees of the Wallingford industrial park could access the trails for exercise and could use the extensive network outside of the EIP for a means of cycling to work.
Wetlands
Large quantities of water are currently being used by the industries and discharged in the Quinnipiac River. Although some of this water is non-contact cooling water, wastewater that comes into contact with chemicals and metals is included in the discharge. This raises the question of how the industries are adversely impacting the quality of the Quinnipiac River and the surrounding ecosystem.

A possible long-term solution to this concern would be constructing wetlands (see Figure 10). Constructed wetlands are designed as a man-made complex of saturated substrates, emergent and submerged vegetation, animal life, and water, that stimulate natural wetlands for human use and benefits. The general components of a natural or constructed wetland include substrates with various rates of hydraulic conductivity, plants adapted to water-saturated anaerobic substrates, a water column, invertebrates and vertebrates, and an aerobic and anaerobic microbial population. Marshes with herbaceous emergent, and perhaps submerged, plants have the most promise for wastewater treatment (Hammer 1991). The microbes found in wetlands use or alter contaminant substances to obtain nutrients and energy to live. The result is a reduction in the amount of contaminant present in the water.

Several studies have shown how constructed wetlands are an effective way to remove contaminants from water. In a study conducted by Weyerhaeuser, artificial marshes were effective at removing nitrogen (organic-N, ammonia, and nitrate), phosphorus, total organic carbon, and color from pulp mill effluents (Hammer 1991). Wetlands have also been shown to remove iron, manganese, and VOCs such as benzene from water (Hammer 1991). The construction of wetlands along the Quinnipiac River would allow microbes to feed off these same contaminants, reducing the overall amount entering the river.

A major limitation to constructed wetlands is the amount of land needed. This would not be a significant concern because there are several acres behind Cytec that are available for development. Aesthetic concerns could also be addressed through a constructed wetland. A wetland creates a natural habitat for wildlife. New flora and fauna would soon arrive, making the appearance of the industrial buildings and their surrounding more pleasing. Finally, creation of new wetlands might allow the EIP to receive benefits through organized wetlands banks that could fund the endeavor.

The issues tackled in the long-term scenario are clearly ones not needing immediate attention. As the priority issues are faced, however, the Wallingford EIP can focus on long-range sustainability concerns. By extending its reach from near-term matters to more overarching areas, Wallingford will become a leader in environmental management.
CONCLUSION: THE POTENTIAL OF THE WALLINGFORD EIP

Wallingford has two key ingredients that make it an ideal candidate for successful creation of an eco-industrial park: businesses with overlapping inputs and outputs, and attractive business amenities that can induce the siting of additional EIP partner industries. Perhaps as important, however, is the willingness of the existing businesses and Wallingford’s Economic Development Coordinator to work with each another to achieve the potential efficiencies of an EIP arrangement. The next step of the project should be to investigate these proposed opportunities for their potential to produce favorable returns on the necessary investments of time and money.

The requisite scale of business partners will be an essential variable in evaluating the return on investment. The existing businesses are limited in the quantity of materials that they can provide to residue processors or purchase from new suppliers. It is questionable whether these transactions will be sufficient enough to merit the siting of a new facility. New facilities in Wallingford might operate at a scale that is not economically favorable to competitors in the sector.

In this regard, the existence of facilities and suppliers elsewhere serves as a barrier to the successful siting of new businesses in Wallingford, or any other medium-scale EIP. If these barriers cannot be overcome, the viability of EIP development may be dependent upon shrinking the minimum efficient scale of target industries. Conversely, EIPs might be most successful in areas that support a cluster of related industries en masse—such as wood finishing and furniture-making in North Carolina or auto-makers and suppliers in Detroit.

As an example, the proposal to develop additional metal processing industries in Wallingford may suffer competitively from utilizing inputs at less than efficient scales. Although the mini-mill seems like part of the ideal solution to the question of metal residues disposal, there are still issues needing to be addressed. The major concern arises when looking at the economy of scale. The Wallingford EIP does not generate enough metal scrap and residue to sustain any of our proposed new industries. Currently, the Wallingford steel industry is producing only 18 million pounds per year, an amount far below what is needed to run a mini-mill. Nucor, a pioneer in mini-mill development, suggests a baseline of 400,000 to 500,000 tons per month of steel in order for a mini-mill to be economically feasible.

In addition to scrap metal quantity requirements, there are quality issues that need to be considered. The steel used by the mini-mill must be high quality with little or no copper content (Davis, personal communication). One solution to the problem of insufficient metal scrap volume would be to contact other steel manufacturers in the area (North Haven, Meriden) and to pool metal residues generated, by consolidating them in the Wallingford EIP. The problem with scrap metal quality is harder to resolve because of the different steel requirements of the industries.
Another issue that could pose a problem for the mini-mill idea is the quality of metal that each industry needs. Connecticut Steel, for example, uses plain carbon steel billets, with a carbon content between 0.04-0.7%. Because Ametek is producing electronic connectors, it has high quality standards for its raw material. The inclusion of Ametek may also be difficult due to the superior prices it receives internally for its recycled metals, due to their specialized formula. The other area steel businesses may have similar needs for specific raw material that may not fully be met if they were to use raw materials generated by any of the proposed new enterprises.

In spite of these constraints that may limit the potential to attract new industries to partner with the Wallingford EIP, our team believes that organizing the existing businesses around an EIP offers substantial, independent benefits. First, the businesses and community stand to benefit from the redirection of material flows in an EIP: businesses can profit from the cost reductions that emerge from more efficient use of raw materials and waste residues, while the whole community can expect to enjoy the fruits of improvement to the local environment.

Secondly, the Town of Wallingford can piggyback on the EIP investments of the businesses to create additional inducements for new business generation. Specifically, Wallingford can contribute to the laying of materials pipelines to create a ready-made industrial campground, as previously detailed. Such shared development will put firms and the government on the same side in promoting the project and reducing the costs for all participants.

Finally, promotion of virtual EIPs, creation of an industrial campground, and integration of existing industries into an ecological and aesthetic plan can serve as the central theme for future development in Wallingford. Such a unified vision could rightly be termed a sustainable development plan for Wallingford that would further integrate firms into the natural environment and the progressive community. This vision could establish Wallingford as a national model for sustainable development, differentiate it from other Northeastern neighbors, and offer the town a significant competitive advantage versus other communities.

ACKNOWLEDGEMENTS

The Wallingford Eco-Industrial Park team is thankful for the enthusiastic support received from the many contacts made in the Wallingford area. Not only was our team afforded site visits, but there were many follow up requests for information which received quick and complete responses. We thank the following organizations and their representatives:

- Ametek: Jack Easley, Fred Ewing, and Joseph Ricketts, Jr.
- Connecticut Steel: Gus Porter
- Cytec Industries: Charlie Cappannara
- Resource Recovery: Leon Plumer
- Suzio Concrete: Len Suzio
• Town of Wallingford: Don Roe, Ray Smith, Eric Kruger
• Ulbrich Specialty Steel Mill: Jerry Goudreau

Last, and certainly not least, our team is thankful for the guidance and many insights received from the Industrial Ecology course professors and support staff: Marian Chertow, William Ellis, Thomas Graedel, Reid Lifset, Janet Testa, and Robert Klee.

REFERENCES
Davis, Linda. Personal conversation regarding the Nucor facility. April 1999.
APPENDIX A  Ametek Specialty Metals

General
What are the products and services of this facility?
- Produce electronic connectors for electronic applications from metal powders; involves:
  1. continuous strip or sheet manufacturing involving high electricity input
  2. wire – either redrawn or from powders
  3. specialized powders for shaped components

Is production seasonal, continuous, or batch?
- components are batch, while all others are continuous

Inputs
Raw materials (type and quantity, purchase quantities, quality)

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>QUANTITY/Details</th>
</tr>
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<tbody>
<tr>
<td>WATER</td>
<td>80,000 gallons per year of city water for cooling</td>
</tr>
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</table>
| ENERGY    | Natural Gas: 40,000 cubic feet per year  
            Electricity: 8 M kWh per year |
| METALS    | Nickel: 1.5 MM pounds, Iron: 0.6 MM pounds,  
            Copper: 0.5-0.25 MM pounds; Chrome alloys, other  
            metals as low quantity additives |
| STEAM     | None |
| OTHER     | Gases: Nitrogen: 5 MM cubic feet per month,  
            Hydrogen: 4 MM cubic feet per month;  
            Lubricating oils, chlorinated solvents |

Outputs
Types and quantities (include physical state, concentration, or purity)
- muffle gases are consumed in process
- metal wastes consist of 90-95% solids, plus some contaminated powders and cinder cakes
- recycled by parent in Pennsylvania because transportation relatively cheap in light of 25% price premium internally
- mineral-based lubricating oils (few thousand gallons annually)
- capture and distill solvents for degreasing; bottoms to recycler

Describe materials reuse or recycling currently being done (onsite and offsite)
- 15-20,000 lbs/year of copper/nickel/tin alloy with concentrations too high for traditional copper uses; again to Pittsburgh returned to powders
- nearly all other waste recycled
- send melt stock (off-specification, pure product) to Pittsburgh; recycle to powders
- 2% sold as scrap locally - degraded or contaminated to scrap dealer
- separate residues by alloy or chemical
Co-products and by-products produced
Would like to sell:
• iron and alluminide alloy powder; few thousand pounds per year
• off-specification but pure iron powder with high carbon content; 200,000 lbs/year

Other
Vacant areas or buildings
• no available space; have 18 acres limited by wetlands
• need space to expand (check nearby neighbors)

APPENDIX B  Connecticut Steel

General
What are the products and services of this facility?
• produce plain carbon steel wire rod (2/3 are coils, 1/3 are added to reinforcing products)
Is production seasonal, continuous, or batch?
• continuous
What are the primary processes used on the site?
• rolling of steel billets to wire rod
• drawing of wire rod to wire
• melting of wire to reinforcing products

Inputs
Raw materials (type and quantity, purchase quantities, quality)

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<tr>
<th>WATER</th>
<th>49 M gallons per year</th>
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<tr>
<td>ENERGY</td>
<td>Natural Gas: 270 cubic feet per year; Electricity: 32 M kWh per year</td>
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<tr>
<td>METALS</td>
<td>Plain carbon steel billets: 600 M lbs per year</td>
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<tr>
<td>STEAM</td>
<td>none</td>
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<tr>
<td>OTHER</td>
<td>small quantity of chemicals to treat water</td>
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</tbody>
</table>

Outputs
Types and quantities (include physical state, concentration, or purity)
• mill scale (6 M lbs/yr)
• scrap metal (15 M lbs/yr)

Describe materials reuse or recycling currently being done (onsite and offsite)
• scrap metal is picked up by a company in Waterbury that eventually recycles it in Pennsylvania

Co-products and by-products produced
• none
APPENDIX C  Cytec Industries

General
What are the products and services of this facility?
• comprised of three groups: Cytec Industries (resins), A.C. Molding (thermosets) and Cyro Industries (thermoplastics)
• resins used in: paint, adhesives, water treatment chemicals, and paper products
• thermoset moldings for: dinnerware, electrical breakers, wallplates, and handles for kitchen utensils
• thermoplastic moldings for: battery cases, refrigerator trays, glasses, and medical devices

Is production seasonal, continuous, or batch?
• continuous

Inputs
Raw materials (type and quantity, purchase quantities, quality)

<p>| | |</p>
<table>
<thead>
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<th></th>
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<tbody>
<tr>
<td>WATER</td>
<td>1.5 T gallons per year</td>
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<tr>
<td>ENERGY</td>
<td>Electricity: 48 M kWh per year</td>
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<td>METALS</td>
<td>None</td>
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<tr>
<td>STEAM</td>
<td>130,000 lbs/hour</td>
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<tr>
<td>OTHER</td>
<td>Formaldehyde (44%), Ethanol, Methanol, Butanol, Iso butanol, Melamide, Natural gas, No. 6 fuel oil, Nitric acid, Acrylonitrile, Methyl methacrylate, Toluene, Ethyl acrylate, Urea, Acrylonitrile, Styrene</td>
</tr>
</tbody>
</table>

Outputs
Types and quantities (include physical state, concentration, or purity)
• waste water (non contact waste water: 365 M gallons/year; processed waste water: 1 T gallons/year)
• waste with BTU value (70,000 gallons/year)
• waste sludge (50 wet tons, 12% solids)
• ensolve (bromine base) cleaner
• oil with water (1,000 gallons/month)
• oily sand from filtration system (3,000 K/month)

Describe materials reuse or recycling currently being done (onsite and offsite)
• thermoplastic resins spilled are reused on-site
• waste plexiglas is sold for recovery
• waste solvents sent to cement kiln in New York
• plastic patty cake reintroduced or sold for sewer pipe manufacturing

Co-products and by-products produced
• milled powder currently being landfilled
Other
Vacant areas or buildings
• roughly 100 acres of vacant land between existing plant and river
Experience with purchasing or selling waste material
• steam experience with Waste to Energy, but discontinued because Resource Recovery switched to electrical generation

APPENDIX D  Resource Recovery Facility

General
What are the products and services of this facility?
RRF is a waste-to-energy plant. It mass burns municipal solid waste (MSW) using the heat produced to run an electric generator, then the electricity is sold.

Is production seasonal, continuous, or batch?
• continuous; stopped twice per year for maintenance

What are the primary processes used on the site?
• MSW is sorted to remove large metal objects, which can cause problems in the burner
• MSW is hydraulically pushed into fire for burning
• heated gases rise, turning generator
• waste gas is sprayed with lime slurry before being released to the atmosphere
• fly ash mixed with burner’s bottom ash, then landfilled

Inputs
Raw materials (type and quantity, purchase quantities, quality)

<p>| | |</p>
<table>
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<tbody>
<tr>
<td>WATER</td>
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<tr>
<td>ENERGY</td>
<td>Diesel fuel: 120,000 gallons/year</td>
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<tr>
<td>METALS</td>
<td>none</td>
</tr>
<tr>
<td>STEAM</td>
<td>none</td>
</tr>
<tr>
<td>OTHER</td>
<td>MSW</td>
</tr>
</tbody>
</table>

Outputs
Types and quantities (include physical state, concentration, or purity)
• electricity (78,840 kwhr per year)
• steam (45,000 pounds/hour)
• ash (43,000 tons/year)

Describe materials reuse or recycling currently being done (onsite and offsite)
• none

Co-products and by-products produced
• none
APPENDIX E  Ulbrich Specialty Strip Mill

General
What are the products and services of this facility?
• produce plain carbon steel wire rod (2/3 are coils, 1/3 are added to reinforcing products)

Is production seasonal, continuous, or batch?
• continuous

What are the primary processes used on the site?
• rolling of steel billets to wire rod
• annealing
• slitting
• cleaning (high pressure hot water, solvents)
• tool grinding

Inputs
Raw materials (type and quantity, purchase quantities, quality)

<table>
<thead>
<tr>
<th></th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>12,000 gallons per year</td>
</tr>
<tr>
<td>Energy</td>
<td>Natural Gas: 6 M cubic feet per year; Electricity: 10 M kWh per year</td>
</tr>
<tr>
<td>Metals</td>
<td>Stainless and high temperature alloys: 20 M lbs per year</td>
</tr>
<tr>
<td>Steam</td>
<td>1,000 lbs per hour</td>
</tr>
<tr>
<td>Other</td>
<td>Gases: Nitrogen (10 M lbs per year), Hydrogen (65 M lbs per year), Argon (5 M lbs per year)</td>
</tr>
</tbody>
</table>

Outputs
Types and quantities (include physical state, concentration, or purity)
• oily cleaning water (4K gallons/week)
• grinding swarf (12 55-gallon drums/year)
• methylene chloride still bottoms (1 55-gallon drum/year)
• ensolve (bromine base) cleaner
• oil with water (1,000 gallons/month)
• oily sand from filtration system (3,000 K/month)

Describe materials reuse or recycling currently being done (onsite and offsite)
• 3 M pounds/year of scrap metal is collected and shipped off-site for recycling

Co-products and by-products produced
• none