CONSULTANT'S REPORT

INDUSTRIAL MINERALS OPPORTUNITIES IN PULP AND PAPER IN BRITISH COLUMBIA TO THE YEAR 2003

Prepared by:

Temanex Consulting Inc.

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Executive Summary And Recommendations

This report, prepared for the British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Survey Branch, provides a detailed overview of B.C.'s pulp and paper industry, with major emphasis on opportunities for high value mineral pigments. It should serve as a starting point for closer development of the two primary B.C. resources, woodfibre and minerals, in a synergistic, mutually beneficial manner.

British Columbia Pulp And Paper Industry Overview

British Columbia accounts for about 35% of total Canadian pulp and paper products, and its pulp and paper industry is only second to Quebec's. The province has been blessed with high quality woodfibre and water resources, as well as relative proximity to one of the largest and most dynamic markets in the world, namely the Western USA. As a result, B.C.'s pulp and paper industry, from the beginning of the 20th century until the 1990's, was commodity product driven, to satisfy the demands of North American and overseas markets for relatively low value-added, resource type products, specifically market pulp and newsprint. Although the most modern of the big three Canadian pulp and paper producing provinces, B.C has the lowest degree of pulp into paper integration, i.e. its products are more resource-based than those of the other two, Quebec and Ontario. Only about 40-45% of total pulp produced in B.C. is converted into paper in the province. The rest is exported to other paper producers around the world and thus the addition of value to the resource does not take place in B.C.

The situation has changed dramatically in the last 5-10 years. Wood costs have continued to escalate, as the available resource became increasingly utilized, and as increasing amounts of forest land has been turned into nature reserves. At the same time, low wood cost competitors, in particular Brazil and Chile, have emerged to challenge B.C.'s position in the global markets for pulp.

Compounding the problems facing the industry, the large US market, which accounts for about 60% of B.C.'s newsprint shipments, starting about 4 to 5 years ago, began legislating significant recycled fibre contents in newsprint printed in US states. Unfortunately, as a result of B.C.'s small population base, its own paper consumption is very low relative to production and therefore there are inadequate supplies of wastepaper for recycling to satisfy the US market's demands.

Finally, a third major challenge has been the market-driven demand for minimization, and ultimately elimination of chlorine in pulp bleaching. This was the result of recent concerns with the production of highly toxic dioxins in the pulp bleaching process when chlorine is utilized. The trend away from chlorine bleaching affects B.C.'s largest single pulp and paper industry product, namely bleached market kraft pulp. Bleached market pulp represents close to 70% of the total pulp production in the province, which (total pulp) exceeds 5 million tonnes annually. Unfortunately, converting to alternative bleaching processes carries enormous capital and operating costs, at a time when the industry has had 2-3 years of very substantial losses.

<u>The only way for the industry to maintain a healthy presence on the world market is to move up to higher value, pigmented paper products.</u>

Papermaking Pigments And Pigmented Papers

It should first be noted that this market study does not include talc which in North America, at least for the time being, is not a true papermaking pigment. Its major end use in the pulp and paper industry is as a pitch and stickies control agent. The primary papermaking pigments are kaolin (clay), calcium carbonate (natural/ground or precipitated) and titanium dioxide. Pigments are utilized either as fillers in the body of a sheet of paper, or applied as coating on the paper surface, with the primary objective, in both cases, to enhance optical properties, (e.g., sheet brightness, opacity, gloss), printability and raw material economy.

Printing and Writing (P&W) papers account for over 95% of paper industry demand for mineral pigments, and they are the focus of this report. Pigment content may range from 2-5% for lightly pigmented products to 30% for heavily filled or coated grades. Well known pigmented papers are photocopy grades, with about 15% filler pigment by weight, and coated magazine grades, with about 25-30% coating pigment by weight. For mineral pigments to be of use as paper pigments, they must have low abrasiveness, a fine particle size distribution, high brightness and high light scattering power. Coating grades must also possess the right rheological flow properties.

Reasons For Low Pigment Utilization By The B.C. Paper Industry

In our opinion, the primary reason for low papermaking pigment utilization not just in B.C. but in all of Western North America, is the very high transport cost penalty for shipping the traditional paper pigment, kaolin, from its natural source in the US South to the West Coast. This transport cost is of the order of CAN $200/MT for the popular calcined kaolin grades. A second reason is the concentration of printing industry activity in North America in the US Midwest and Northeast, resulting in a corresponding heavy concentration of pigmented papers manufacture in these two regions.

As mentioned above, the situation will be changing in the future, as the B.C. paper industry restructures, by moving to higher value, pigmented products. Local pigment sources will minimize the financial pain of shipping large amounts of pigment from the US South. This should create significant opportunities for the development of potential new, B.C. supplies of mineral pigments for the paper industry.

One way for the paper industry to reduce pigment transport costs was offered in the 1980's with the development of precipitated calcium carbonate (PCC) technology. The PCC process produces calcium carbonate pigment at the mill site, or within a short distance of a number of mills, thereby eliminating, by and large, pigment transport costs.

The Outlook For Papermaking Pigments To The Year 2003

Based on a most likely forecast for papermaking pigments demand between 1993 and 2003, we forecast that **total Western North American paper industry demand for pigments will increase from 300,000 to 750,000 tonnes/year, or about 10% per annum.** This is about 3-4 times the projected annual growth in total regional paper production, i.e. pigmented papers will be favoured over non-pigmented ones. **B.C.'s share of 55,000 to 60,000 tonnes per year in 1993 is forecast to grow to 180,000 to 190,000 tonnes/year in the year 2003, i.e. a 12% per annum growth rate.** A structural change in the papermaking pigments market, in particular in B.C., will be a significant shift towards coating pigment grades, since coated paper production is forecast to grow faster than the production of uncoated papers. Regarding mineral pigment types, the current balance of roughly 50:50 between kaolin and calcium carbonate should shift more towards kaolin as a result of increased coating applications. A ratio of 75:25 (kaolin:calcium carbonate) is projected to the year 2003. However, evolving technology allowing the use of calcium carbonate in mechanical pulp-based papers, and the possibility of low cost calcium carbonate supply to the B.C. Coast (about Can $200/MT), may somewhat slow down the growth of kaolin consumption.

Recommendations For The B.C. Geological Survey

The broad recommendation is to identify a mineral pigment product and market development strategy in order to capitalize on the forecast aggressive evolution of the B.C., and total Western North American paper industry, into high value, pigmented paper products. Some specific recommendations are:

a) Sponsor, in conjunction with mineral properties owners, technical trials to define the potential suitability of B.C. mineral pigments in papers. These trials should include, in addition to known/established chemical analyses:

- Grinding and wet processing to produce the appropriate particle size distribution for papermaking end uses, both filler and coating;
- Calcining (where appropriate);
- Measurement of basic papermaking pigment quality parameters - particle size, abrasiveness, brightness, light scattering coefficient and, for potential coating grades, rheological flow properties.

b) Based on the work in (a), define the most promising mineral sources/types for follow-up pilot papermaking trials. These should include low cost, laboratory handsheet studies to produce both woodfree and groundwood type papers containing mineral pigments, to be followed by pilot scale trials on experimental paper machines, and finally full scale commercial machine trials.

c) Both kaolin and calcium carbonate (the Texada Island properties are already feeding limestone raw material for the production of precipitated calcium carbonate at fine paper mills in the US Pacific Northwest). In addition, the potential of high purity and brightness gypsum, from Northwestern B.C., should be explored for specialty coating mixtures.

d) A full, mill-by-mill database containing papermaking mineral pigment consumption, and basic pigment type and quality, as well as demand growth trends, should be produced and maintained on an annual basis.

e) A basic pre-feasibility study, including transportation cost analysis to market, should be carried out for the most promising, potential papermaking pigment properties.

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1.0 Introduction

The British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Survey Branch has commissioned Temanex Consulting Inc. to prepare a report which will analyze the current B.C. pulp and paper industry position, and forecast future trends to the year 2003. The main objective of this analysis is to define major shifts in papermaking raw material consumption by B.C.'s pulp and paper industry, with special emphasis on industrial minerals. The conclusions and forecasts will facilitate B.C.'s Geological Survey to maximize opportunities for high value industrial minerals development in the province.

The B.C. pulp and paper industry is export oriented and is one of the major suppliers of market pulp and newsprint on the international markets. Therefore structural changes in this industry will be driven by :

- Worldwide demand trends;
- Competitive position of the B.C. industry in the global market;
- Raw material supply limitations;
- Technological changes; and
- Environmental constraints.

Worldwide demand for pulp and paper products is forecast to increase significantly, particularly in the emerging economies of the Pacific Rim and Latin America. Growth rates in highly industrialized North America, Western Europe and Japan, which currently account for 75-80% of paper consumption, will be slower, due to market maturity.

The highest growth rate is expected in printing and writing (information) papers. These grades use significant amounts of mineral pigments. At the same time rapid technological changes, driven mainly by the environmental concerns and changes in environmental legislation, will influence the industry structure. More demanding product quality standards are emerging, particularly in the newsprint, uncoated and coated groundwood papers, and woodfree printing papers.

Mineral pigments, able to impart unique quality characteristics to paper, which are not achievable with wood pulp alone, will play an increasingly important role as a papermaking raw material in the future. At the same time, technological developments in papermaking and new "engineered" pigment products are opening opportunities for an increasingly diverse number of mineral pigments to be used in enhancing paper quality.

B.C. has been blessed with relatively abundant high quality fibre and energy, fundamental prerequisites for a robust and healthy, but commodity resource product oriented pulp and paper industry. One of the key current and future realities is an increasingly competitive world, with lower wood cost competitors, such as Brazil and Chile, being able to offer cost-competitive pulp products on the world market. A second one is market/environmental pressures to incorporate increasing amounts of recycled fibre in newsprint and, eventually, other printing papers. This negates much of B.C.'s fibre quality and energy cost advantages, especially since B.C.'s population and paper consumption are both very small, compared to the size of its newsprint industry. Therefore wastepaper availability is quite limited and inadequate.

Clearly to maintain a strong competitive presence in world markets and healthy industry, B.C.'s pulp and paper industry will have to move towards high value products requiring increasing amounts of mineral pigments.

2.0 Current B.C. Pulp & Paper Industry Perspective

2.1 Overview

The purpose of this chapter is to identify special attributes and characteristics of B.C.'s pulp and paper industry, in order to allow for a more meaningful and focused analysis of the potential for industrial mineral consumption, patterns and trends.

The B.C. pulp and paper industry evolved in the first half of the 20th century driven by:

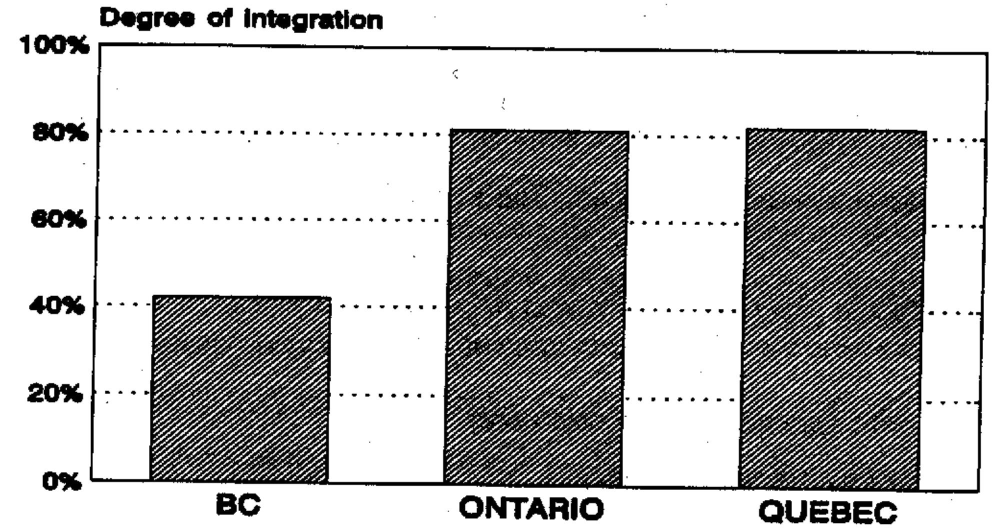
- Abundant, high quality, low cost fibre;
- Low cost hydroelectric power;
- A booming US West (California) market, particularly for newsprint.

These factors combined to establish a largely commodity, resource-product-based industry in the province. Today, B.C.'s pulp and paper industry is the second largest in Canada after Quebec's and it is the most modern of the three big producers, Quebec, Ontario and B.C. At a total output of about 7 million MT/Year, it accounts for about 35% of Canadian production of finished pulp and paper products.

Over the years the industry performance has fluctuated, thriving at the peak and suffering at the bottom of economic cycles on export driven commodity newsprint and market pulp.

The B.C. pulp and paper industry has a low degree of integration. Of the total production of 7 million tonnes, about 2.7 million tonnes are various grades of paper (mostly newsprint) and about 4.3 million tonnes are market pulp. In paper production, B.C. producers used about 2.6 million tonnes of integrated pulp. The B.C. pulp and paper industry produces a large quantity of primary product, market pulp, and a lower quantity of value added paper products. Its degree of integration, defined as the percentage ratio of (Total Paper production)/(Total Pulp Production) is the lowest of the big three producing provinces as shown in Figure 2-1.

Figure 2-1
THREE BIG CANADIAN P&P PRODUCERS
DEGREE OF INTEGRATION (TOTAL PAPER/TOTAL PULP)



Temanex Consulting Inc.(FIG2-1)

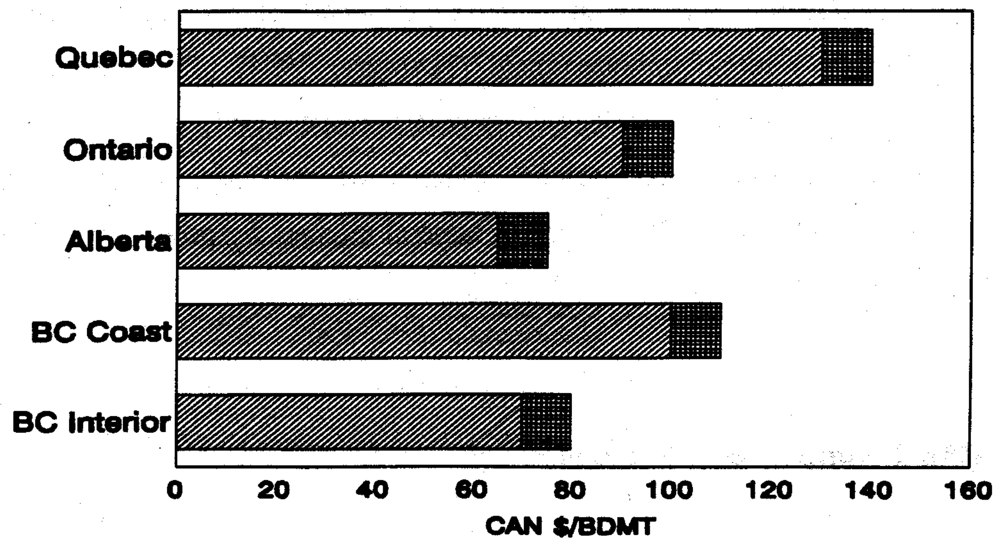
During the last 10-15 years some of the factors that have driven the development of the B.C. Pulp and paper industry, have changed dramatically. Wood, particularly on the earlier exploited B.C. Coastal region, has become increasingly scarce and expensive. At a cost of about Can $100/BDMT, it is the second most expensive in Canada, as shown in Figure 2-2A.

B.C. with its hydroelectric generation still has low power costs, as shown in Figure 2-2B. Low electricity costs were very advantageous in the past when there was demand on the export market for virgin fibre newsprint. B.C.'s prime export market, the USA, now demands recycled fibre in newsprint. There are two disadvantages to B.C. originating from this development:

a) Recycled fibre requires only about 300-400 kWh/MT of electricity, compared to 2000-2400 kWh/MT for TMP/CTMP, the most cost competitive newsprint fibre.

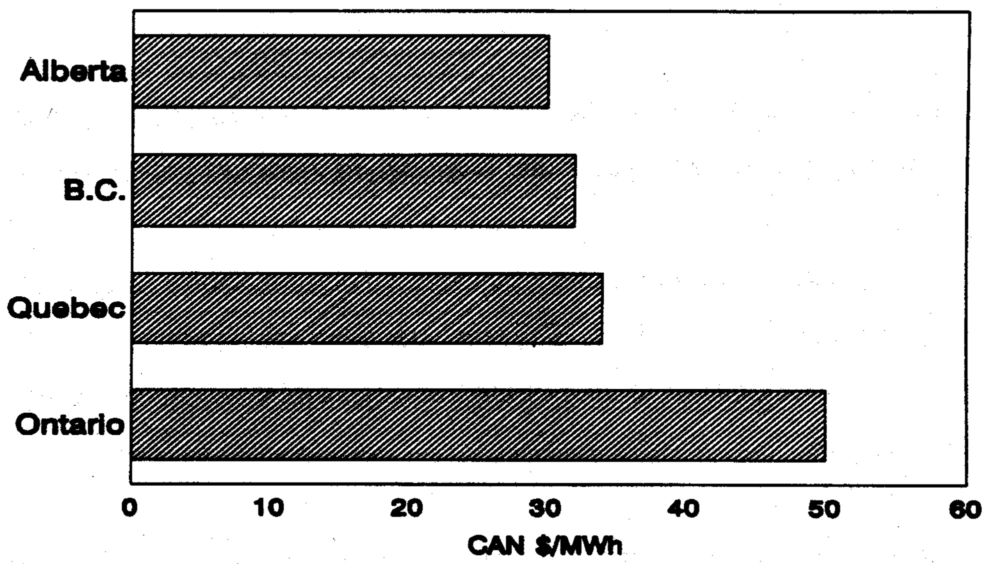
b) As a result of B.C.'s small population, wastepaper availability is very limited, thereby constraining the B.C. newsprint industry's ability to compete in the large US market.

Figure 2-2a
TYPICAL CANADIAN REGIONAL SOFTWOOD CHIP COSTS
(FOR PULP)



Temanex Consulting Inc.(FIG2-2a)

Figure 2-2b
CANADIAN COMPARATIVE POWER COSTS



Temanex Consulting Inc.(FIG2-2b)

The only viable option to remedy the B.C. pulp and paper industry's problems, as several B.C. pulp and paper executives have indicated in the last 2-3 years, lies in moving from commodity, resource driven products to higher value and quality printing papers. These are the grades which utilize significant amounts of mineral pigments for cost and quality optimization. MacMillan Bloedel's recent announcement (February, 1994) of conversion of the largest newsprint machine at the Port Alberni mill to coated groundwood, is one example of the future evolution of the industry. This machine, which used zero percent mineral pigment when producing newsprint, will use 25-30 percent mineral pigment by product-weight beginning end of 1995 or early 1996.

2.2 End Products and Markets

B.C.'s major pulp and paper products are commodity market kraft pulp and newsprint. These are primary resource products, mainly produced for the export market. In recent years B.C. has increased production of mechanical pulp, largely TMP and CTMP, as well as mechanical pulp-based printing and writing papers. These grades will account for a growing share of B.C.'s future production growth in pulp and paper, since they take advantage of B.C.'s high quality fibre and low cost electricity.

B.C. producers also manufacture linerboard and sack kraft paper, recycled paperboard, woodfree printing and writing paper, tissue paper and construction grades of paperboard.

Table 2-1 summarizes types and annual tonnages of various pulps, paper and paperboard products produced in B.C. in 1992-93. The numbers in this table are based on 1992 production statistics and have been adjusted to 1993 using Temanex estimates, since not all 1993 data are available at this point.

Figure 2-3 shows the breakdown of major pulp and paper products manufactured and shipped by B.C. pulp and paper mills in 1993.

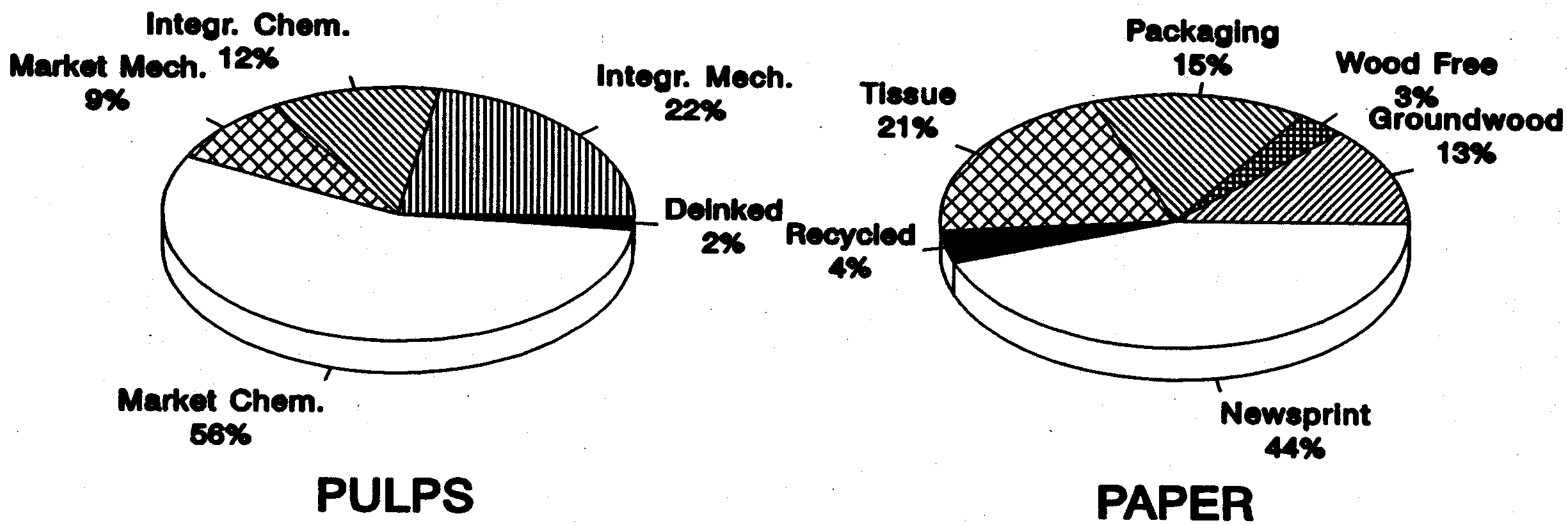
Table 2-1

PULP, PAPER & PAPERBOARD PRODUCTS PRODUCED IN B.C. IN 1992/93[1]

PRODUCT		ANNUAL PRODUCTION (MT/YR)
<u>PULPS</u>		
Mechanical Pulps		
SGW	Stone Groundwood (Integrated)	230,000
RMP	Refiner Mechanical (Integrated)	180,000
TMP/CTMP	Thermomechanical (Integrated)	1,100,000
TMP/CTMP	Thermomechanical (Market)	600,000
Chemical Pulps		
UBK/SCH	Unbleached Kraft/Semichemical (Integrated)	500,000
SBK	Semi bleached kraft (Integrated)	300,000
FBK	Fully bleached kraft (Market)	3,800,000
Recycled		
DEI	Deinked Fibre	112,000
<u>PAPER AND PAPERBOARD PRODUCTS</u>		
NEW	Newsprint	1,500,000
GWD	Groundwood specialties	420,000
UWF/CWF	Uncoated & Coated Woodfree P & W paper	125,000
UPP	Unbleached packaging papers	500,000
TSP	Tissue and sanitary papers	80,000
REC	Recycled packaging papers	140,000

1 Data in the above table is based on the published production statistics for 1992 and was adjusted to 1993 using Temanex estimates.

Figure 2-3
B.C. PULP & PAPER INDUSTRY
1992/93 PRODUCT BREAKDOWN



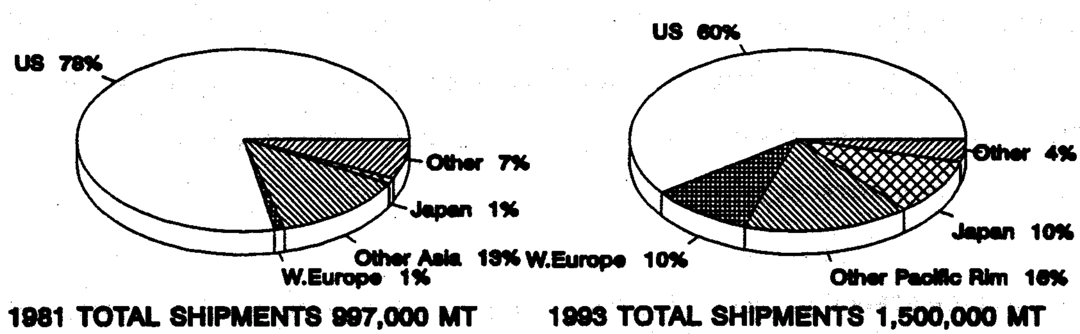
Temanex Consulting Inc.(FIG2-3)

2.2.1 Newsprint

Newsprint, by definition falls in the category of communication papers that weigh between 40 - 57 g/m^2, although most tonnage is at 48.8 g/m^2. The furnish is largely mechanical pulp with some reinforced chemical pulp. In North America this grade of paper generally does not contain mineral pigments.

In 1993 B.C. produced about 1.5 million tonnes of newsprint, and exported most of it. Figure 2-4 shows B.C. exports of newsprint by purchasing regions in the year 1981 and 1992.

Figure 2-4
B.C. SHIPMENTS OF NEWSPRINT
1981 and 1993



Temanex Consulting Inc.(FIG2-4)

The U.S.A. continues to be the largest market, absorbing more than half of total B.C. newsprint export. In recent years, the U.S. share has declined, from 78% in 1981 to 60% in 1993. The U.S. will continue to represent a reduced market share. B.C. shipments into Asian and Western European markets have increased steadily in the past decade. Asia Pacific accounted for 14%

of B.C. newsprint export in 1981 and for about 26% in 1993. Shipments to Japan, Taiwan and Australia were the largest Pacific Rim markets for B.C. B.C. exports into Western Europe grew from 1% in 1981 to 10% in 1993. Exports into other markets, such as Latin America and the Middle East have declined through the 1980s.

2.2.2 Printing and Writing Papers

Printing and writing papers are of particular interest in this report since they are by far the largest consumers of minerals. This category includes coated and uncoated groundwood papers, and coated and uncoated woodfree papers.

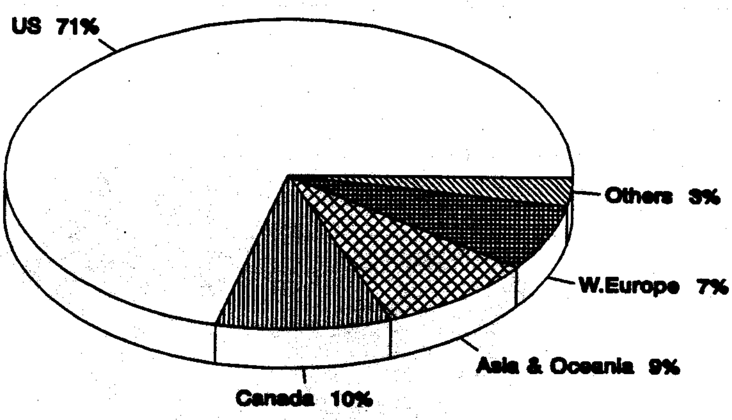
Groundwood Publication Papers

Groundwood publication papers is a diverse group of papers, which includes papers for magazines, catalogues, inserts, telephone directories, books etc. These grades contain primarily mechanical pulp (anywhere from 65% to 100%) and may contain mineral pigments ranging from 0 to 30% depending on grade. Current grades of groundwood papers produced in B.C. contain from 0 to 10% mineral pigments.

Uncoated groundwood papers, with respect to quality and price/value, are somewhere between newsprint (lowest quality) and coated groundwood. Coated groundwood is the highest quality groundwood publication paper with 25-30% pigment content and one to which an increasing capacity will be dedicated to in the future.

In 1993, B.C. produced just over 420,000 MT of uncoated groundwood publication papers almost all on the B.C. Coast, with a small amount at an Interior newsprint mill. There were no coated groundwood papers produced. As shown in Figure 2-5, 71% was exported to the U.S., mostly to the West Coast. About 10% stayed in Western Canada, about 9% was exported to Asia and Oceania, 7% to Western Europe and 3% to other countries.

Figure 2-5
B.C. SHIPMENTS OF GROUNDWOOD PUBLICATION PAPERS
1993



1993 TOTAL SHIPMENTS 420,000 MT

Temanex Consulting Inc.(FIG2-5)

For the moment, these grades use almost exclusively water-washed and calcined kaolin:

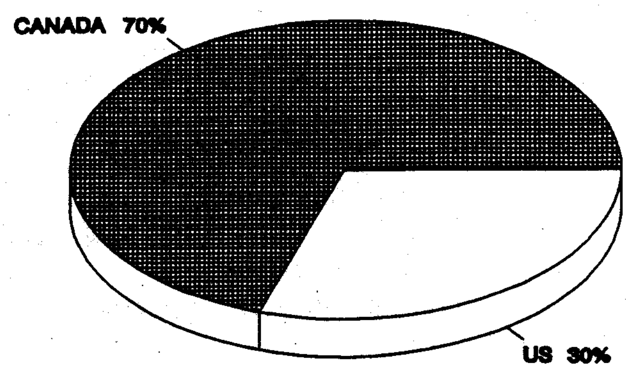
Woodfree papers

Coated or uncoated woodfree papers contain at most 10% of mechanical pulp, and usually 0 percent. They are commonly made with bleached kraft pulp and may contain 12 to 20 percent mineral pigments if uncoated, and 25 to 35 percent if coated. At present, these pigments are almost exclusively precipitated (for uncoated) and ground (for coated) calcium carbonate. They cover a wide range of end uses, such as printing papers, bond, ledger, duplicating, envelope, catalogues, magazines etc.

British Columbia has one manufacturer of woodfree printing and writing paper, namely Island

Paper mills in New Westminster, producing about 125,000 MT a year. This mill sells approximately 70% of its woodfree papers in Canada and the remaining 30% is exported to the Western U.S., as illustrated in Figure 2-6.

Figure 2-6
B.C. SHIPMENTS OF WOODFREE PAPERS
1993



1993 TOTAL SHIPMENTS 125,000 MT

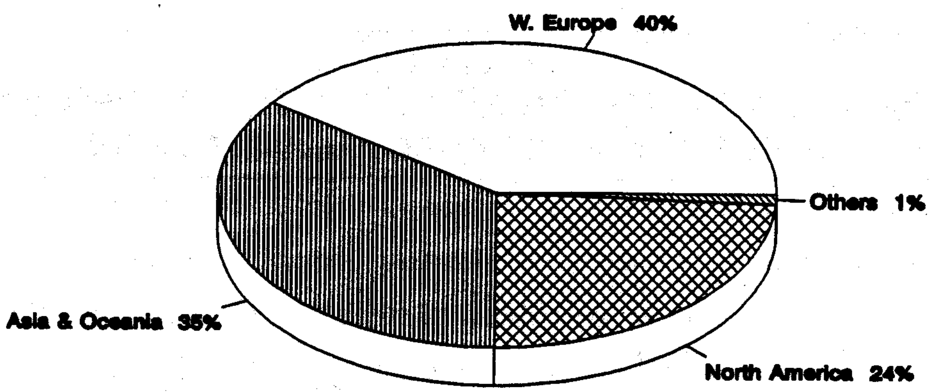
Temanex Consulting Inc.(FIG2-6)

2.2.3 Unbleached Packaging Papers

These papers are made predominantly from wood pulp produced by the sulphate pulping process (kraft pulp) or semichemical pulping process. They are comparatively coarse, noted particularly for their strength. They can be converted into a wide variety of products such as grocer's bags, envelopes, wraps, boxes, etc. These paper grades do not contain mineral pigments.

B.C. is Canada's largest exporter of kraft paper and paperboard products, with most of its production going to export. In 1993 B.C. produced about 500,000 MT of Kraft Paper, of which about 24% was shipped to North America, 35% to Asia and Oceania, 40% to Europe and 1% to other markets, as illustrated in Figure 2-7.

Figure 2-7
B.C. SHIPMENTS OF UNBLEACHED PACKAGING PAPER
1993



1993 TOTAL SHIPMENTS 500,000 MT

Temanex Consulting Inc.(FIG2-7)

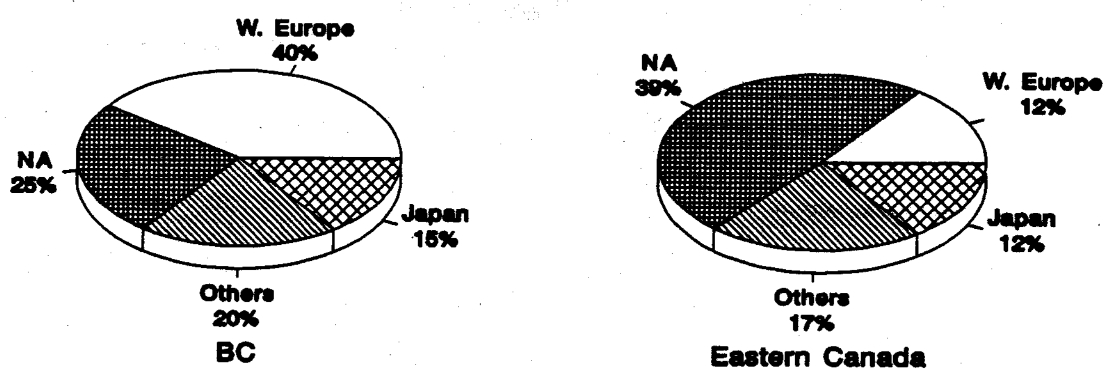
2.2.4 Other Paper Products

In 1993 B.C. produced about 300,00 tonnes of other papers, such as tissue, recycled paper and paperboard and construction grades of paperboard. The tissue is sold mostly in Western Canada, while about 25% of the remaining paper goes to the Western US and 75% stays in B.C. and Alberta. These grades of paper do not include mineral pigments, except for a small coating operation of recycled paperboard in Burnaby.

2.2.5 Market Pulp

In 1993 B.C. pulp and paper mills had a total installed virgin market pulp fibre capacity of just over 8 million tonnes, or 48.3% of total Canadian capacity. More than half of the total pulp produced in B.C. is market pulp, sold to virtually every world market. B.C. produces both mechanical (CTMP) and chemical (FBK) market pulp. Figure 2-8 depicts the estimated breakdown of market pulp shipments to the various world regions compared with Eastern Canadian and U.S. producers.

Figure 2-8
1993 ESTIMATED MARKET PULP SHIPMENT
PERCENTAGES BY PURCHASING REGION



Temanex Consulting Inc.(FIG2-8)

The pulp distribution and marketing strategy is influenced by accessibility, essentially where total transportation costs are relatively low. Rail freight to most Eastern US destinations is much higher than ocean shipping, especially for B.C. coastal mills, which therefore ship most of their product by ocean freight to Europe and the Pacific Rim.

2.3 Raw Materials Composition in Papers

Today's paper producers produce thousands of different types of paper and paperboard. The basic raw materials in these products are:

- Pulps (virgin and/or recycled), and
- Mineral Pigments.

Some of the papers, such as newsprint can be manufactured using a single grade of pulp. However, more often, papermakers will blend different kinds of pulp to produce a unique set of physical properties, while at the same time attempting to minimize costs. For example, by adding kraft pulp to mechanical pulps, the necessary strength of printing papers is achieved. While most pulps could be adapted to a variety of applications, each is a natural candidate for a specific type of papers. Mineral pigments are generally added to coated and uncoated groundwood papers and coated and uncoated woodfree paper to improve texture, opacity, gloss, smoothness, brightness and overall printability of the finished product.

2.3.1 Pulps

In B.C. wood provides the basis for virgin pulp production. To this raw material a complex chemical and/or mechanical process is applied to produce various mechanical or chemical pulps.

Mechanical pulps

These high yield (90 -97%) pulps have the following characteristics:

- High content of original wood, providing economic advantage;
- High bulk, opacity and absorbency advantages to some printing papers;
- Relatively low strength due to mechanical damage to the wood fibre in the pulping process;
- Tendency of lignin to yellow, thus discoloration or loss of brightness in finished papers.

The following mechanical pulps were produced in B.C. in 1993

- Stone Groundwood (SGW);
- Refiner Mechanical Pulp (RMP);
- Thermomechanical Pulp (TMP);
- Chemi-thermomechanical Pulp (CTMP).

Stone groundwood, refiner and thermomechanical pulps, with relatively low cost, high opacity and excellent adaptability to printing applications are used in newsprint, directory, and catalogue papers, as well as lightweight coated and supercalendered papers used in advertising and inserts.

Chemical Pulps

These pulps have the following characteristics:

- Yield between 40 and 55 percent of original wood, thus higher cost;
- Longer and more flexible fibres, thus producing stronger pulps;
- Easier to bleach and less likely to lose its brightness over time.

The following chemical pulps were produced in B.C. in 1993

- Unbleached Kraft (UBK)
- Semibleached Kraft (SBK)
- Fully Bleached Kraft (FBK)
- Semi Chemical Pulp (SCH)

Kraft pulps are the most widely used of all pulps. Small amounts can be added to virtually any paper to improve strength. Thus it is a common component in newsprint, tissue towelling and food containers. Semichemical pulps have exceptional stiffness and are ideally suited for the middle layer of corrugated boxes.

Recycled Pulps (Deinked Fibre)

The use of recycled pulps in the paper furnish is steadily increasing in North America mainly due to environmental considerations. These pulps have the following characteristics:

- Lower brightness and lower quality than virgin fibres;
- Shorter lifespan.

In B.C. recycled pulps are used in the production of newsprint and groundwood papers, as well as recycled paperboard.

2.3.2 Pigments

Pigments are used in the paper industry, both in paper filling and in paper coating. When used in paper filling they alter physical properties of paper such as brightness, opacity, surface smoothness, ink strike through etc., and they may reduce raw material cost per unit area of paper by extending fibres. When used in coating, pigments improve brightness, smoothness, gloss, ink hold out and in some instances add bulk to coating for specific end uses.

The three most important pigments in the paper industry, based on tonnage are:

- Kaolin, also known as China Clay or simply Clay;
- Calcium Carbonate, which nowadays is either Ground (GCC) or Precipitated (PCC); and
- Titanium Dioxide.

In addition, there are a number of specialty products such as precipitated silicas or silicates, barium sulfate, and so on. These are generally costly and have only small, specialty end-use application.

Kaolin, a fine particle size, white pigment, is the most widely used mineral in the paper industry. The clays used in the paper industry are classified by particle size, brightness and end use. kaolin is used, nowadays, primarily in coated and uncoated groundwood papers.

Calcium Carbonate has traditionally been used in the manufacture of alkaline papers (primarily copy papers), as a filling pigment, as well as for the production of high brightness, low gloss coated papers. Its major limitation has been its high abrasivity and lack of gloss. Recent developments in the process technology of ground calcium carbonates, have allowed the production of less abrasive, higher glossing carbonates.

Titanium Dioxide is an inert, white pigment, characterized by its high refractive index, which results in high light scatter. The high light scattering properties of Titanium Dioxide make significant contributions to paper brightness and opacity. However at about U.S. $2000/MT FOB (freight on board), it is the most expensive papermaking pigment, used only sparingly in high quality papers.

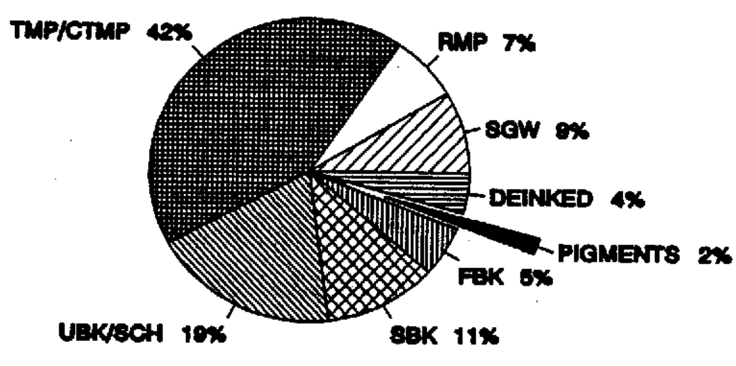
2.3.3 Fibre Furnish in B.C. Paper Production

In 1993 B.C. paper producers produced 2,750,000 MT of various paper products. Total furnish consisted of 94 percent virgin fibre, 4 percent recycled fibre and 2 percent mineral pigments. This is depicted in Figure 2-9.

Figure 2-9

B.C. PAPER INDUSTRY

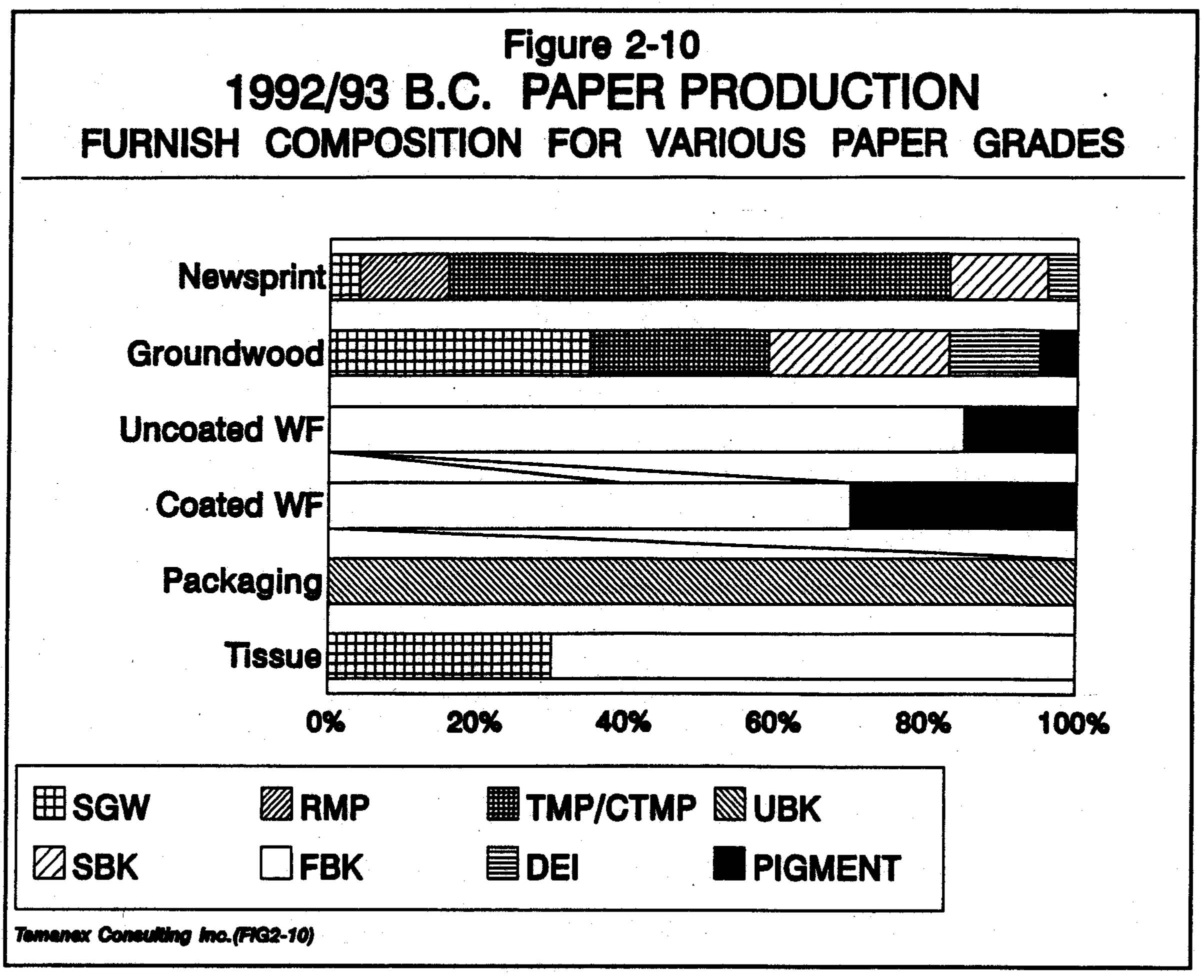
1992/93 TOTAL PRODUCTION FURNISH COMPOSITION



Total Paper Production 2,750,000 MT

Temanex Consulting Inc.(FIG2-9)

The furnish composition for various paper grades is provided in Figure 2-10.



The following pigment grades were used in above paper grades:

- Uncoated Groundwood - Calcined and filler kaolin;
- Uncoated Woodfree - Precipitated calcium carbonate;
- Coated Woodfree - *Ground calcium carbonate and some coating kaolin;*

The above pigments are chosen to provide a combination of quality and cost-effectiveness.

3.0 Constraints on Papermaking Pigment Use in Western Canada

The same reasons which have inhibited papermaking pigments usage in all of Western North America in the last few decades are responsible for the low pigment demand in Western Canada. There are two major, identifiable restraining factors:

- Distant location of Western papermaking plants from the natural source of mineral pigments in the US South.
- Traditional evolution of North American printing markets to favour the US Northeast and Midwest for high quality, pigmented paper printing.

3.1 Distant Location From Mineral Pigment Sources

The distant location of Western Canada, and the rest of Western North America, from the geographical point of origin of, until recently, almost all papermaking mineral pigments used in North America has been a major factor inhibiting papermaking mineral pigment usage in the region. In fact, until the mid-1980's, there was only one uncoated woodfree mill in the province which used mineral pigments.

The traditional point of origin of papermaking mineral pigments (primarily kaolin) is well known to be the US South-Southeast (Georgia and the Carolinas), where abundant, high quality, secondary deposits of kaolin exist. This area supplies not only North American pigment need, but also those of many overseas countries.

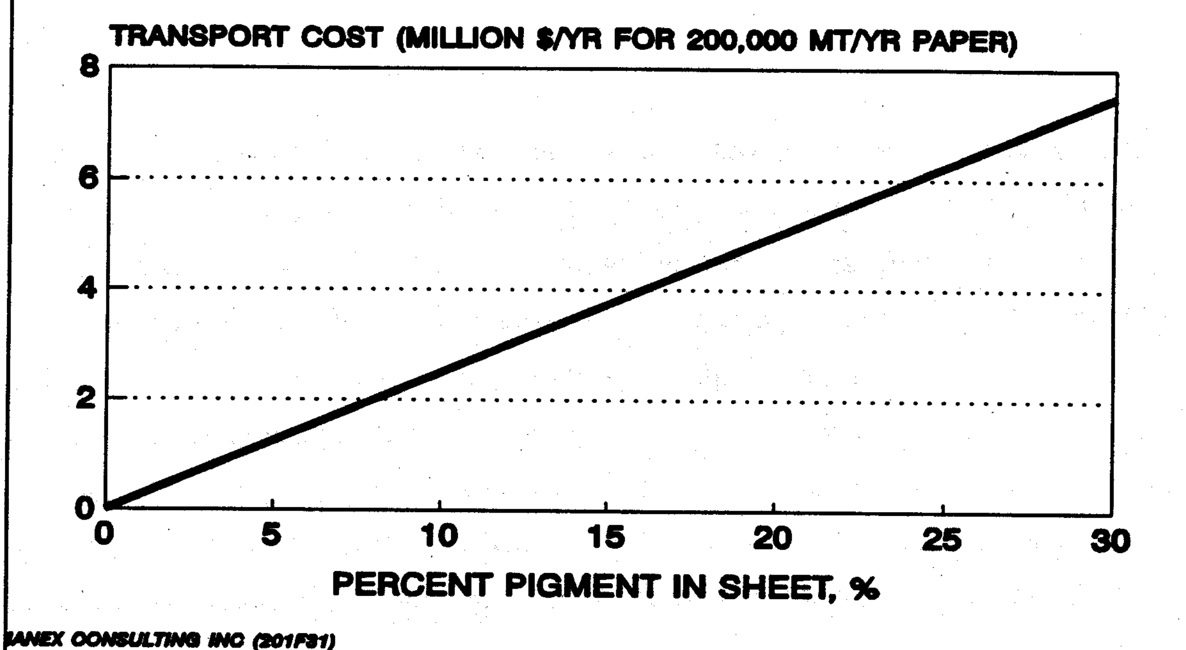
Transportation costs add significantly to the delivered kaolin price, resulting in production cost penalties and reduced cost-competitiveness of Western producers. An example of transportation costs and pigment costs (FOB), based on recent market intelligence from B.C. Coast pigmented groundwood paper producers, is summarized in Table 3-1.

TABLE 3-1
CALCINED KAOLIN COSTS TO BC COAST PAPER MILLS (CAN$/MT)

	FOB Cost, $/MT	Transport, $/MT	Total Cost, $/MT
High Grade-Bags	605	205	810
Low Grade-Slurry	445	220	665

The transport cost is of the order of CAN $(200-220)/MT. A similar transport cost to the US South or Midwest is in the region of CAN $(30-50)/MT, putting the B.C. at an incremental transport cost penalty of about CAN $170/MT. This penalty is lower, at about CAN $110/MT for water-washed kaolin grades, which are easier and cheaper to ship, but it is nevertheless quite substantial. For a paper grade which uses a combination of calcined and water-washed kaolin in the ratio 1:3, and a nominal, world class paper machine of 200,000 tonnes/year capacity, the annual kaolin transport cost penalty for a B.C. Coast machine compared to an equivalent US South or Midwest one is as shown in Figure 3-1 at different pigment percentages in the sheet.

Figure 3-1
INCREMENTAL PIGMENT TRANSPORT COST
BC COAST OVER US SOUTH/MIDWEST



Using Figure 3-1 it can be computed that a coated groundwood machine, such as MacMillan Bloedel's Port Alberni machine will be in 1996, with a 25-30% pigment loading, would carry a CAN $(6-7) million per year incremental kaolin transport cost penalty compared to a US Southern or Midwestern machine. Unless there are other cost advantages for the B.C. machine, such as lower wood, electricity, labour, or transport of the paper product to markets, the B.C. machine will have inferior cost-competitiveness and profitability.

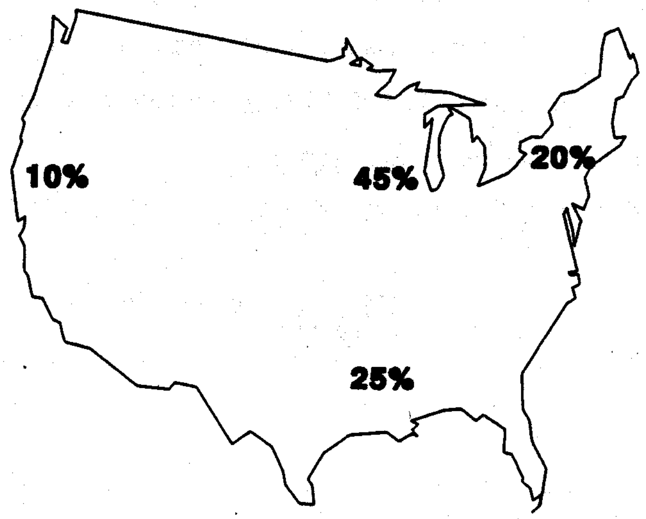
3.2 Evolution of North American Printing Markets

The first areas of North America to be industrialized during the last 100-200 years were the US Northeast and Midwest. The main drivers for the industrial boom in these regions, particularly in the first half of the 20th century were:

- Their geographical position, in relation to the relatively affluent Western European countries;
- Abundance of high quality, low cost raw materials, energy, water transportation and labour.

Robust demand for P&W grades was a natural and essential outcome of these developments. Even today, the US Northeast and Midwest are the destination for about 65% of all US printing and writing paper shipments as shown in Figure 3-2. Essentially, with the printing industry solidly established in these two US regions, a significant portion of printed papers into Western North America are in fact printed in the US Midwest and shipped over the Rockies as finished products. A natural outcome of this was that by far the greatest portion of the most heavily pigmented papers (coated grades) was located near these consuming regions. This has created a "chicken and egg" situation in Western North America. Since there is not enough printing capacity for these high quality papers, manufacturing capacity for these papers has been restricted, and vice versa.

Figure 3-2
USA P&W PAPER SHIPMENTS



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3.3 Influence On Western North American Paper Industry Structure

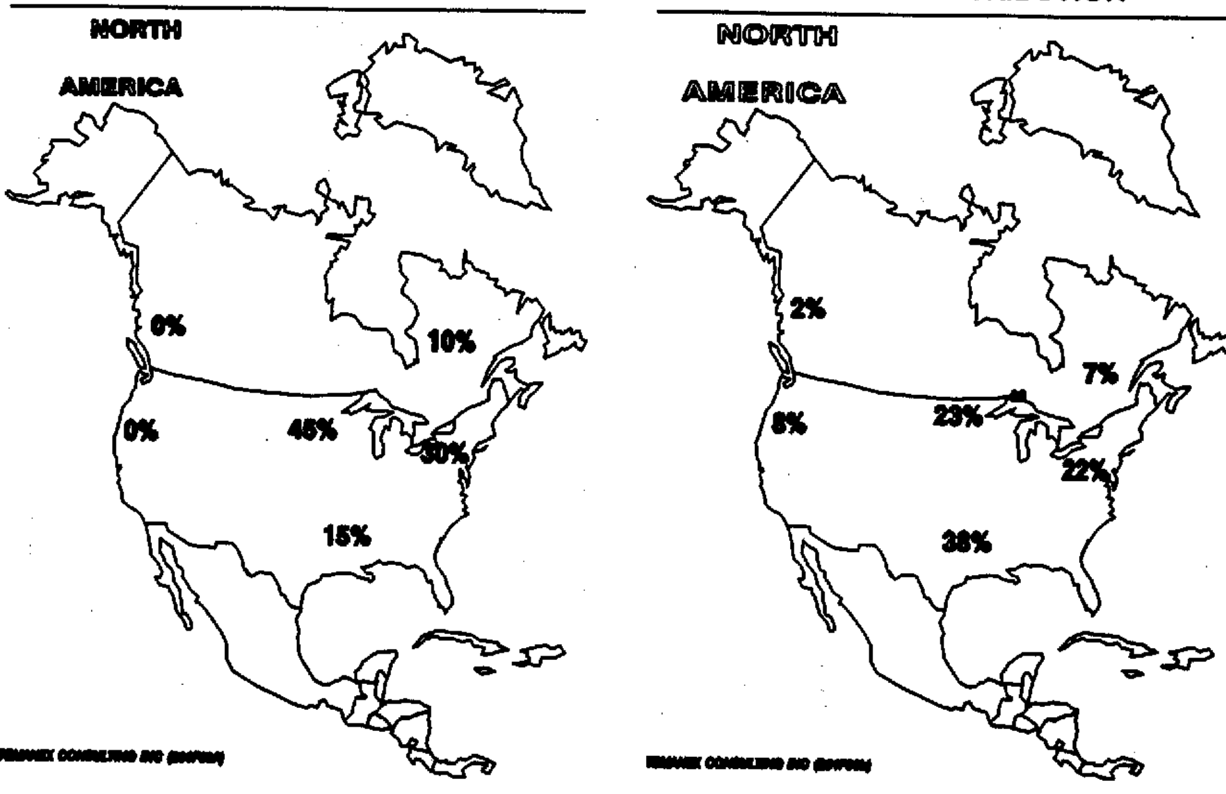
The above developments have combined to create effectively two major geographical producing and consuming paper markets in North America, one West of the Rockies and the second, larger one, East of the Rockies. According to the proportion of the total population and share of economic strength, the Western region accounts for roughly 25% of total North American paper consumption of all P&W grades. However, with regard to installed capacity, there are some notable differences. These are strikingly illustrated in Figure 3-3.

Figure 3-3A shows the coated groundwood papers capacity distribution in North America. It closely reflects the concentration of printing industry activity shown in Figure 3-2. The apparent low capacity share of the US South is largely the result of inferior mechanical pulp quality of the predominant southern pine fibre, compared to the highest quality fibre, northern spruce. This is made up, to a great extent, by the other highly pigmented, major paper grade, uncoated woodfree, a grade made with fully bleached kraft pulp and therefore less sensitive to fibre quality. In this grade, the US South has a 35-40% share of total North American, and the US West and Canada has a significant deficit between demand and supply, and therefore relies on imports from East of the Rockies - see Figure 3-3b.

Figure 3-3

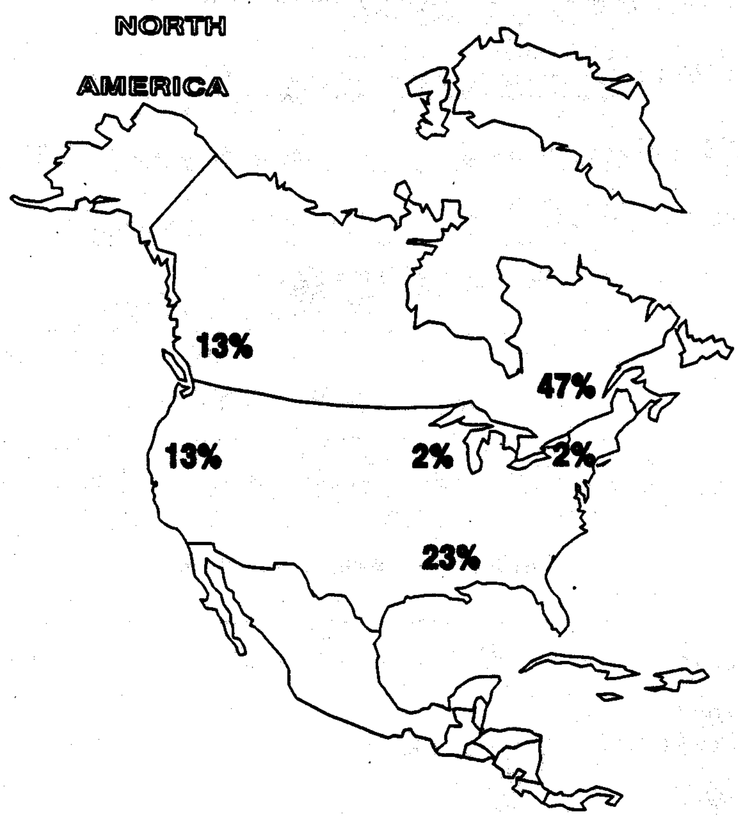
Figure 3-3A
COATED MECHANICAL
CAPACITY DISTRIBUTION

Figure 3-3B
UNCOATED WOODFREE
CAPACITY DISTRIBUTION



In the case of newsprint, on the other hand, the large, non-pigmented printing grade, the Western North American (US and Canada) combined capacity share is 26% of the total, as shown in Figure 3-4. In fact, the region is a net newsprint exporter, primarily to the Pacific Rim.

Figure 3-4
NEWSPRINT CAPACITY DISTRIBUTION



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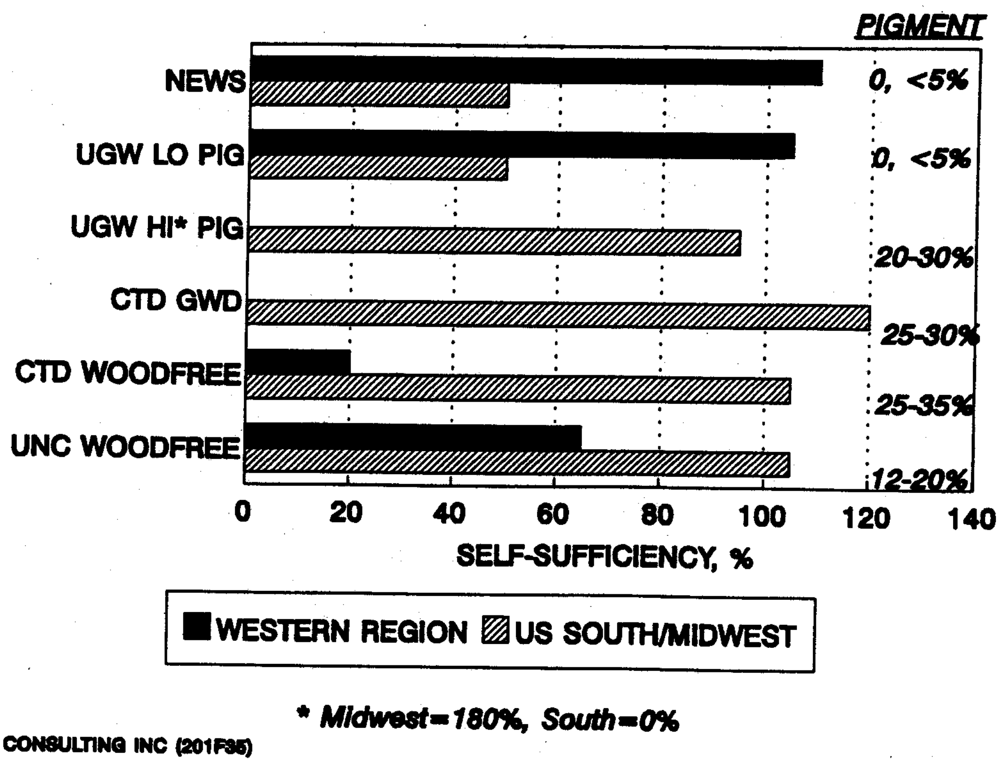
Finally, the most vivid testament to low papermaking mineral pigment utilization by the Western North American paper industry is offered as the self-sufficiency ratio for a number of grades including grade pigment content by weight in Figure 3-5. Self sufficiency is defined as paper capacity for a given grade as a percentage of regional demand. Western North America is deficient in highly pigmented products, whereas the US South and Midwest are more than self-sufficient in these grades.

Figure 3-5
PRINT GRADE REGIONAL SELF-SUFFICIENCY



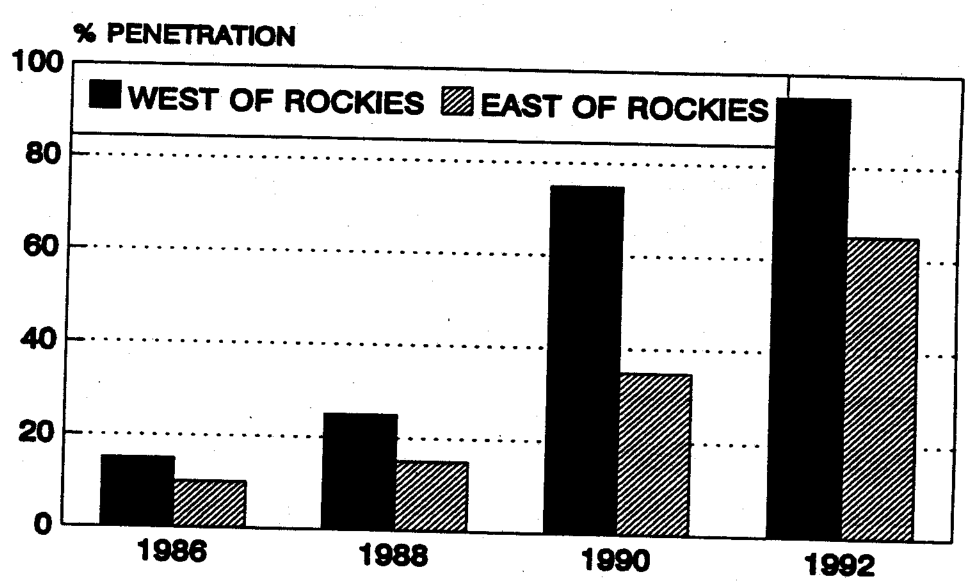
3.4 Alkaline Papermaking And PCC

Beginning in the early 1980's the adoption of neutral-alkaline papermaking conditions for woodfree papers swept through the North American paper industry driven by a number of factors discussed in Section 4.4.2. Europe, with its greater sensitivity to fibre costs as a result of its limited forest resources, was already at a near full penetration of this technology for coated and uncoated fine paper grades for about 10-15 years.

[NOTE: Although the technological problems are being solved, it is still not possible, in general, to incorporate this technology in the manufacture of groundwood papers (those printing papers containing mechanical pulp). The reason is that mechanical pulp fibres turn yellow at alkaline pH, therefore they are normally produced at a pH of about 5. Woodfree papers were also produced at a pH of around 5, until converted to neutral-alkaline conditions. The reason for the conversion was that the new, calcium carbonate pigments used in alkaline papermaking, go into solution at a pH less than 7.]

A major boost to the acceptance of alkaline papermaking technology in North America was provided by the development and implementation of process technology to manufacture, on a paper mill site, precipitated calcium carbonate (PCC). This, essentially, eliminates the transport cost penalty for those mills situated relatively far from the natural pigment sources, as was discussed in the earlier section 3.1. The rate of penetration of alkaline papermaking and PCC was far greater in Western North America than in the rest of North America - see Figure 3-6. Again, the major reason was the far greater sensitivity to pigment transport costs of the Western region, which made an on-site (no transport costs) PCC supply an extremely attractive option.

Figure 3-6
ALKALINE & CALCIUM CARBONATE PENETRATION IN WOODFREE PAPERS



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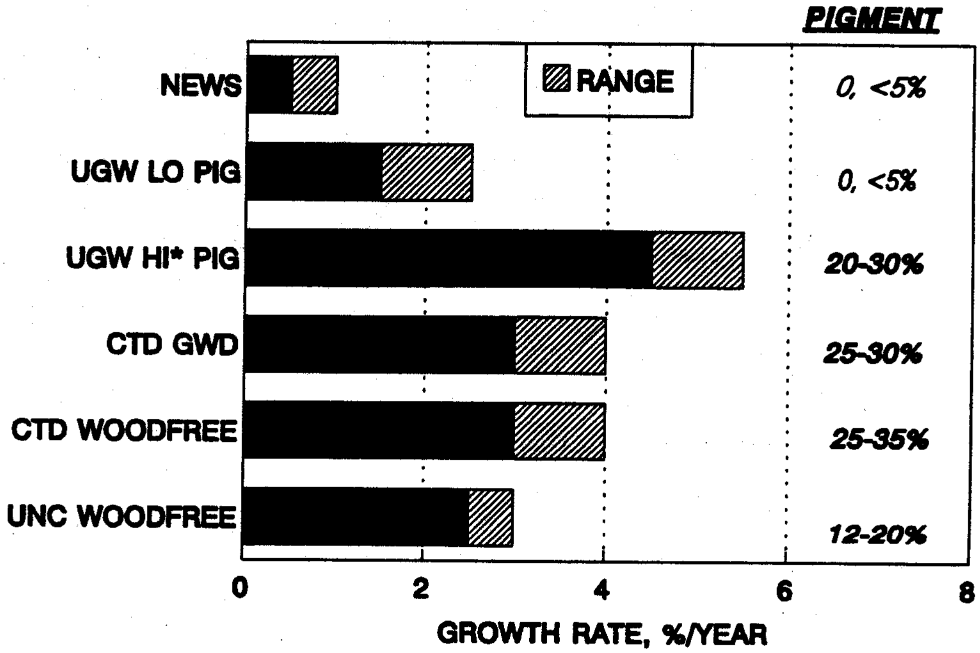
3.5 The Future

The future outlook for increased manufacture of pigmented papers and utilization of mineral pigments in their manufacture is very positive. It will be driven by a number of factors in combination, including:

- The need to impart greater value to an increasingly scarce and costly, yet high quality, fibre resource.
- The disadvantageous position of B.C. newsprint in the large US West Coast market, as a result of the high, legislated post-consumer recycled content demand and the lack of adequate wastepaper supplies in Western Canada to satisfy the mills' needs. This, again, dictates a move out of commodity newsprint and into high value papers.
- The advantageous geographical position of B.C. with respect to the large California and Far East markets.
- Relatively low B.C. power costs favouring the production of high quality, mechanical pulp-based papers, since mechanical pulps are the most electrical energy intensive of all pulps - see also next point.
- Ongoing technological developments which will progressively remove restrictions on the use of calcium carbonates in even mechanical pulp-based papers.
- Ongoing move to higher value products and improved quality for existing products in order to maintain competitiveness. For example, newsprint brightness in North America has increased about 4 percentage points during the last 10 years, as a result of demands imposed by increasingly sophisticated four-colour printing technology. Coated groundwood papers have moved in a similar manner.

- Ongoing growth in P&W grade demand both in North America and globally, with the greatest growth in pigmented papers - see, e.g. long term forecasts of Temanex Consulting for the 1990 to 2000 period percent growth per year in the demand of specific grades in Figure 3-7. The more heavily pigmented products are forecast to grow at about 2-3 times the growth rate of the lightly or not pigmented papers.

Figure 3-7
PRINT GRADE DEMAND GROWTH RATE IN NORTH AMERICA: 1990 TO 2000



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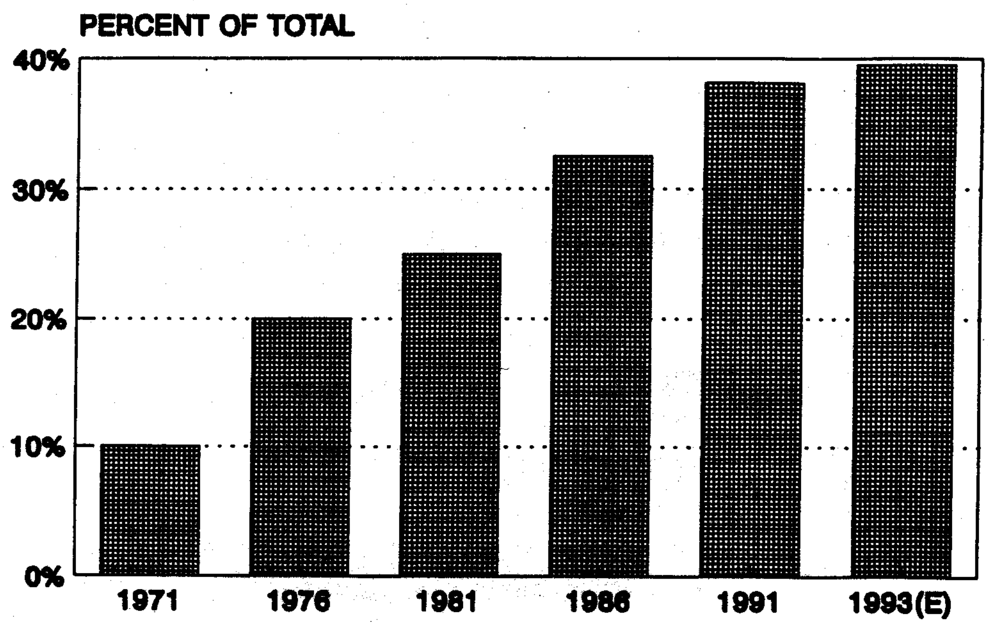
- Continuing move to lower paper product weights to satisfy the demands of end users for economy both in printing and in mailing products such as catalogues, magazines and the like - see Figure 3-8.

Figure 3-8

MAGAZINE PUBLISHERS ASSOCIATION SURVEY OF COATED GWD WEIGHT TRENDS



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4.0 Key Environmental, Market and Technology Drivers

4.1 Environmental Trends

By far the most dominant factors impacting the North American, Canadian and B.C. pulp and paper industry in the 1990's has come from the environmental concerns and changes in environmental legislation, in particular in two major areas:

- Wastepaper recycling; and
- Reduction of organochlorines in bleached kraft mill effluent.

4.1.1 Wastepaper Recycling

In Western Europe and Japan intensive waste paper recycling has been in place for many years, driven by the lack of forest resources and aided by the high population density which permits for low-cost waste paper collection. Waste paper recovery and utilization is a relatively recent development driven not by lack of forest resources, especially in Canada, but rather, by the shortage of landfill capacity causing an explosion in municipal waste disposal costs in some large, densely populated regions of the US Northeast and Eastern Canada. This point is illustrated in Figures 4-1 and 4-2.

Figure 4-1 shows wastepaper utilization rate (percentage of recycled pulp in total paper production) against the logarithm of forest area per capita for major paper producing countries, in 1990 and 1993. Forest-rich Canada has one of the lowest wastepaper utilization rates, although it is increasing as discussed below.

Figure 4-2 shows one of the major wastepaper recycling drivers in North America, namely an increase in landfill tipping fees. In key areas such as Toronto and New York-New Jersey, within a 5-6 year period between the mid-1980's and early 1990's, there has been a ten fold increase.

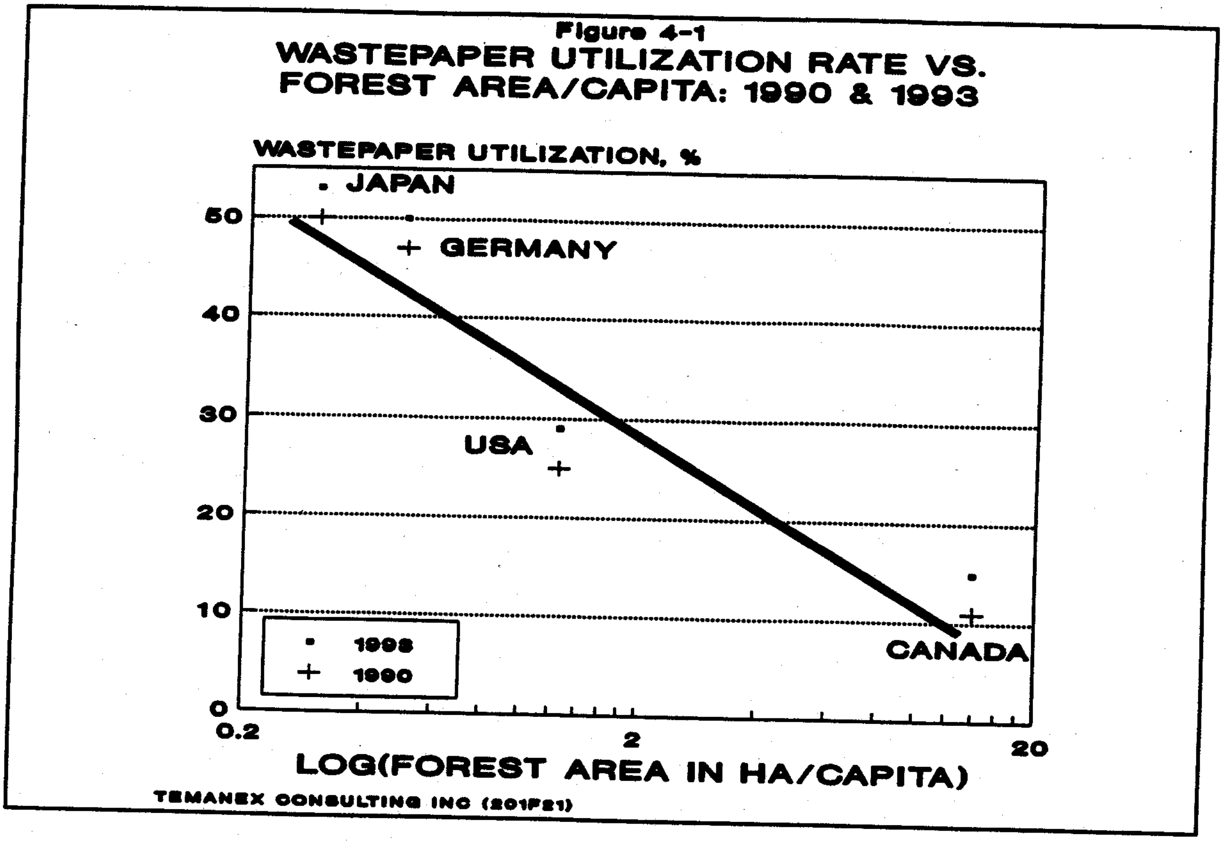
Figure 4-1
WASTEPAPER UTILIZATION RATE VS. FOREST AREA/CAPITA: 1990 & 1993
WASTEPAPER UTILIZATION, %
JAPAN
GERMANY
USA
CANADA
1993
1990
50
40
30
20
10
0
0.2
2
20
LOG(FOREST AREA IN HA/CAPITA)
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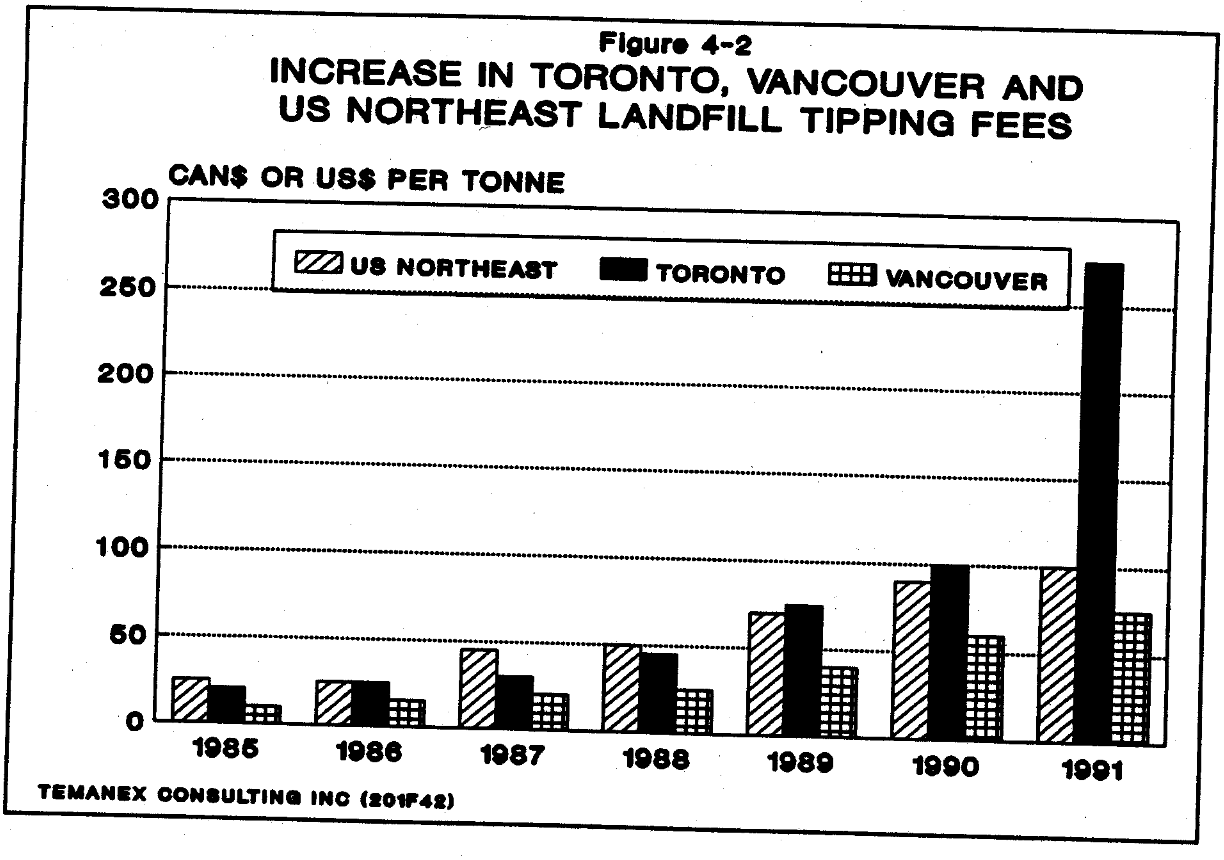
Figure 4-2
INCREASE IN TORONTO, VANCOUVER AND US NORTHEAST LANDFILL TIPPING FEES
CAN$ OR US$ PER TONNE
US NORTHEAST
TORONTO
VANCOUVER
300
250
200
150
100
50
0
1985
1986
1987
1988
1989
1990
1991
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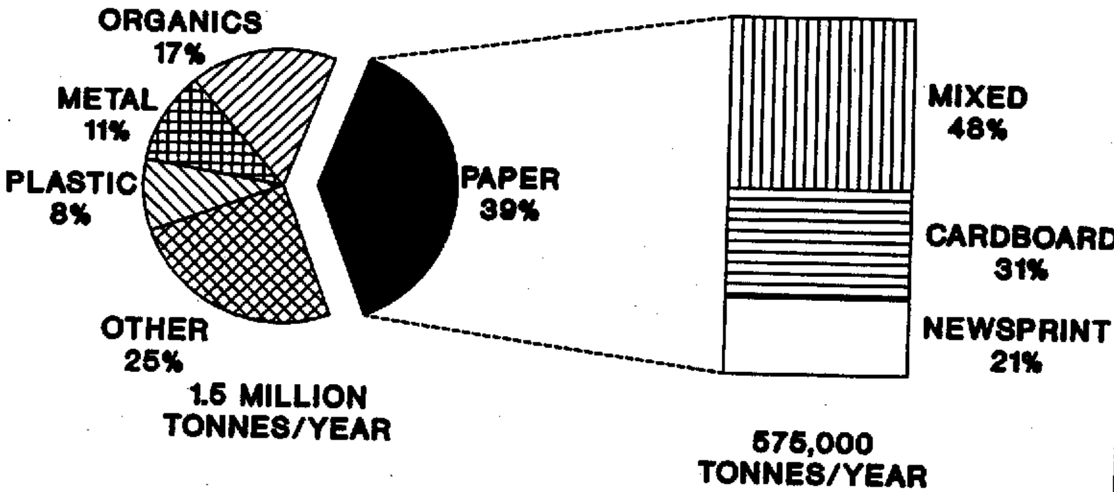
To minimize the adverse impact on public sentiment of tax increases to pay for the incremental landfill tipping fees, various levels of government targeted waste reduction as one way to, at least partially, contain disposal costs and landfill scarcity. Paper and paperboard products constitute about 35-40% of municipal waste, so naturally they were among the first waste products to be targeted for reduction. Figure 4-3 provides a breakdown of the Greater Vancouver Regional District annual waste. The results were obtained from one of the most extensive recent North American studies of municipal waste generation, funded by the GVRD.

Figure 4-3
BREAKDOWN OF GVRD MUNICIPAL WASTE GENERATED ANNUALLY



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One of the easiest wastepaper grades to segregate, and most short-lived papers (usually read one day and disposed of the next day), is newsprint, used for printing newspapers. It, alone, accounts for 8% of North American municipal solid waste. Furthermore, recycling/deinking technology for its re-use in the production of new (recycled) newsprint was well established in Europe, Japan and, more recently, the USA.

In the United States many local and state governments are passing environmental legislation and agreements, defining recycled newsprint requirements as shown in Table 4-1.

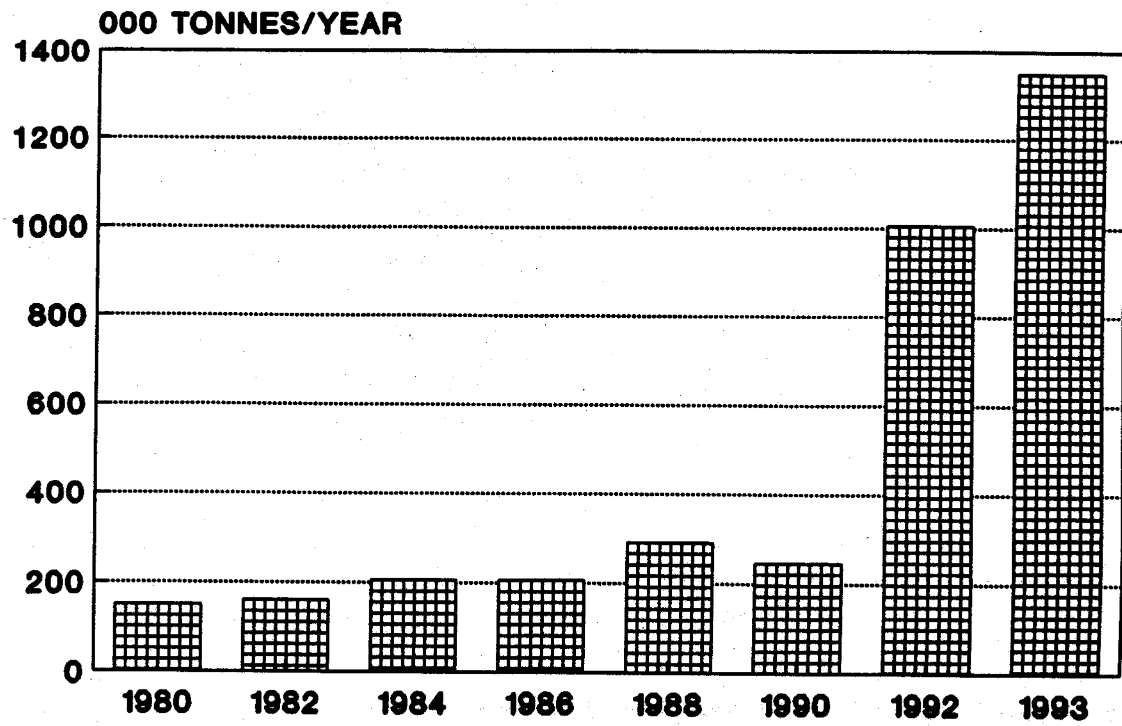
TABLE 4-1
US RECYCLED NEWSPRINT LEGISLATION AND AGREEMENTS - 1993

	1991-92	RECYCLED %	1996 onward	RECYCLED %
	Of Purchases	Of Fibre Used	Of Purchases	Of Fibre Used
LOCAL GOVTS.				
MANDATORY				
Suffolk County, NY	15%	6%*	100%	40%
Washington, DC	12%		20%	
VOLUNTARY				
Broward County, FL	20%		30%	
Miami, FL	20%		30%	
STATE GOVTS.				
MANDATORY				
Arizona	25%	-	35%	-
California	25%	10%	35%	14%
Connecticut	-	11%	-	31%
Florida	-	40%	-	-
Illinois	-	22%	-	28%
Maryland	12%	-	30%	-
Missouri	10%	-	40%	-
North Carolina	12%	-	30%	-
Oregon	-	25%	-	-
Rhode Island	11%	-	31%	-
Texas	10%	-	20%	-
Wisconsin	-	10%	-	35%
VOLUNTARY				
Colorado	N/A	N/A	N/A	N/A
Indiana	-	11%	-	23%
Iowa	-	10%	-	30%
Louisiana	-	10%	-	30%
Maine	25%	-	40%	-
Massachusettes	12%	-	35%	-
Michigan	12%	-	24%	-
New Hampshire	11%	none	31%	none
New York	-	11%	-	31%
Ohio	-	11%	-	23%
Pennsylvania	-	-	35%	-
Vermont	-	11%	-	23%
Virginia	15%	none	30%	none

*15% times 40% minimum content rule

Canada, with its great reliance on the US market, had to move fast to satisfy this market's demand for recycled fibre content, or suffer rapid loss of market share. This is reflected in Figure 4-4 as a sharp increase in Canadian demand of old newspapers and old magazines for recycling in new deinking facilities at Canadian newsprint mills.

Figure 4-4
CANADIAN OLD NEWSPAPER AND OLD MAGAZINE DEMAND TREND



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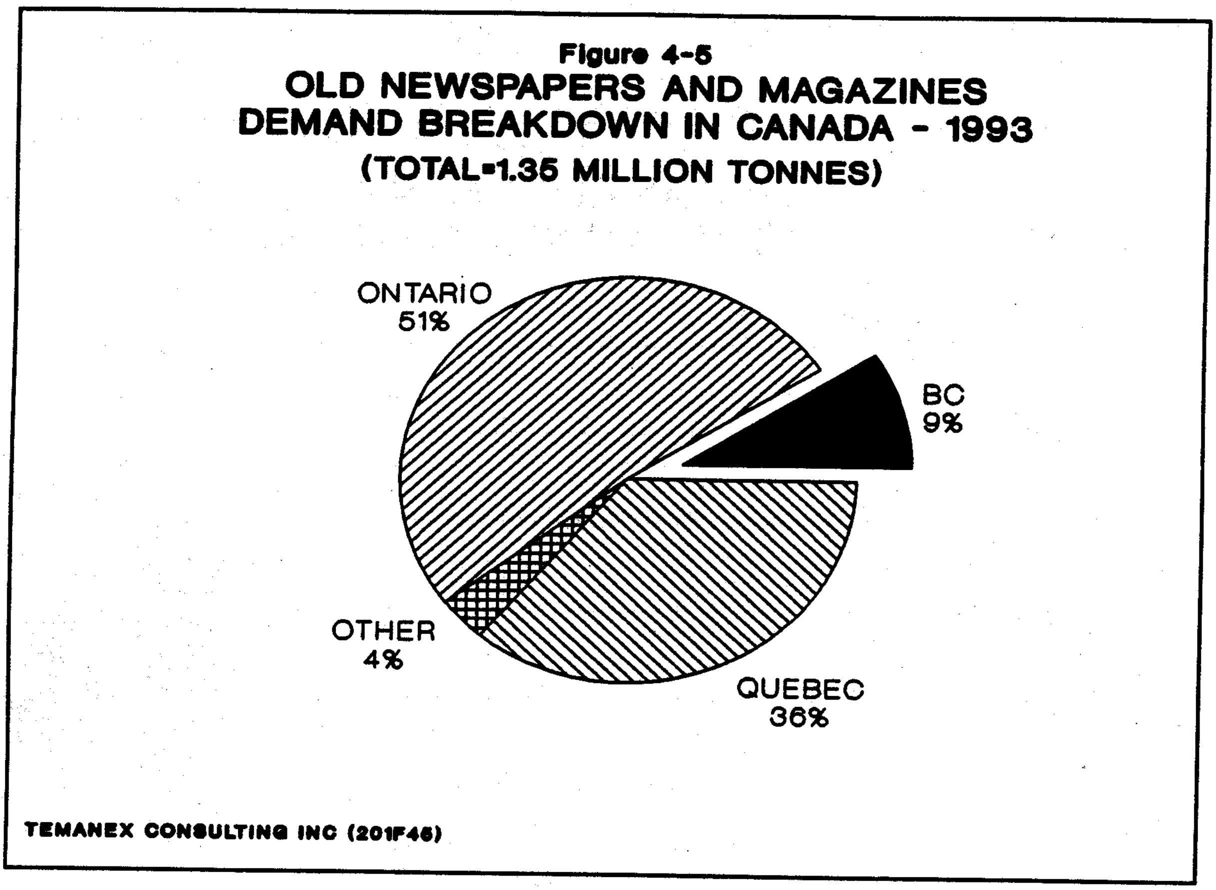
Although the B.C. newsprint is dependent on the US market, its dependence is not as strong as that of Ontario and Quebec (90-100% of newsprint exports from these two go to the USA). Furthermore, availability of wastepaper for recycling, even in the form of imports from Western USA, is much more restricted than it is for the two Eastern provinces. As a result, only one true newspaper and magazine deinking operation (Newstech, Coquitlam, B.C.), whose output is shared between MacMillan Bloedel and Fletcher Challenge Coastal newsprint mills, started up in B.C. two years ago, and B.C. represents a small share of recycled old newspapers and magazines in Canada, as shown in Figure 4-5.



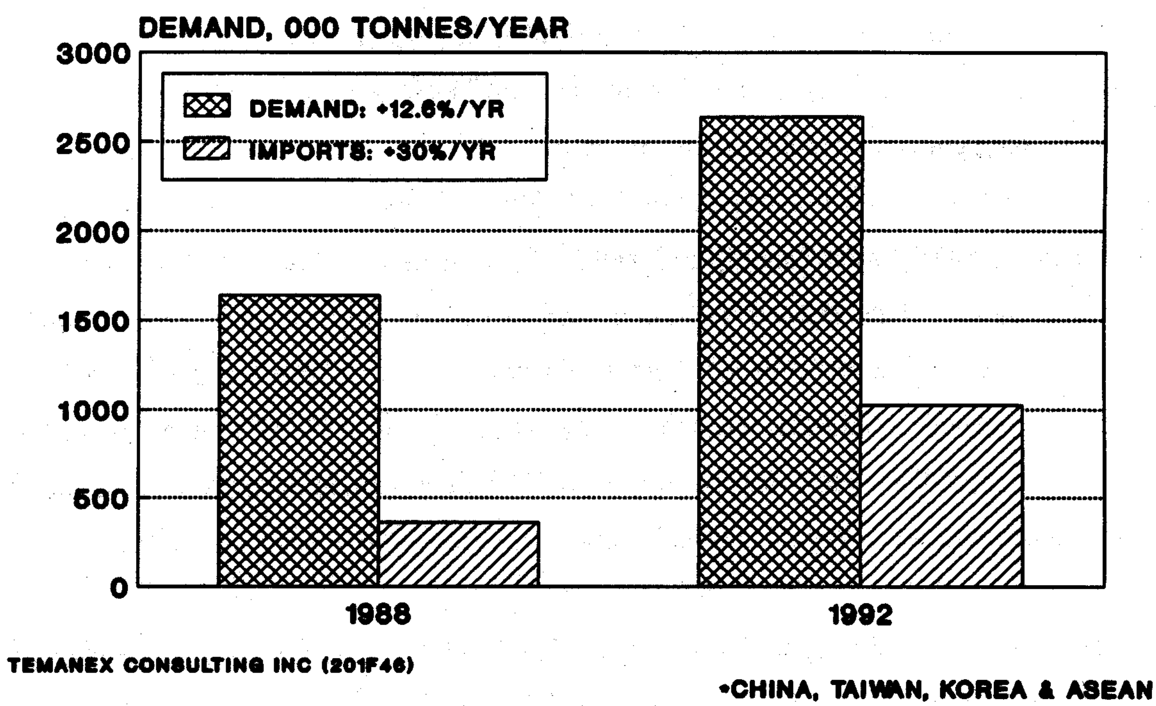
The major impact of recycled pulp in North American newsprint has been to make mineral pigment content generally acceptable in newsprint. Traditionally, with 3-4 notable exceptions, North American newsprint operations used only 100% (virgin) wood fibre. Since coated magazine paper, which is included in most newspaper deinking operations, contains about-25-30% mineral pigment (see earlier chapter 2), some of this pigment ends up in the deinked pulp. It should be noted that this is recycled pigment, and it does not represent a direct market opportunity. However, possible deficiencies in deinked newsprint printability, which mineral pigments may rectify, could offer direct market opportunities for mineral pigments in recycled newsprint and related paper products, such as lightweight telephone directory. Even these pigment opportunities will be limited in Western Canada, however, due to the limited wastepaper availability for deinking, as was mentioned earlier.

As far as the B.C. newsprint industry is concerned, the major shifts arising from the US market's demand for recycled content newsprint will be:

- A move away from newsprint to higher value products which, at least for the time being, do not have as stringent recycled content regulations as newsprint does. We are already witnessing this with the recent (February, 1994) announcement of MacMillan Bloedel that the largest newsprint machine at the Port Alberni mill will be converted to coated groundwood over the next 18-24 months.

- Decreased reliance on the US newsprint market and increased exports to Southeast Asia, whose booming economies are hungry for paper - see Figure 4-6.

Figure 4-6
SOUTHEAST ASIA* NEWSPRINT DEMAND AND IMPORTS



4.1.2 Reduction In Organochlorines In Bleached Kraft Effluent

As seen in chapter 2, by far the largest B.C. pulp and paper industry product is fully bleached market kraft pulp. Although changes in the market pulp industry do not influence papermaking mineral pigments demand (unless of course a paper machine is installed at an existing market pulp mill to produce pigmented papers), this being the largest volume product of the B.C. pulp and paper industry, structural changes in this segment of the industry will undoubtedly have a strong influence on the rest of the industry. It is important, therefore, to understand evolving trends in this major field.

For the last 4-5 years, the bleached chemical pulp industry in North America has been struggling to identify and implement alternative bleaching sequences to the traditional chlorine-based process. This herculean task has been imposed on the industry by external drivers. None of these drivers has been stronger than the need to reduce the formation of organochlorines, which are formed in very small amounts during the chlorine bleaching process. The three focal points of concern have been:

- Dioxins (polychlorinated dioxins and furans) in pulp and effluent;
- AOX (adsorbable organically-bound halogen) in effluent; and
- OX (organically-bound halogen) in pulp.

At some mills, dioxins found in pulp and paper effluent were found at concentrations higher than background levels. This created the initial concern about using chlorine for chemical pulp bleaching. The process really began with the release in 1987 of the US EPA (Environmental Protection Agency) National Dioxin Study (EPA 440-/4-87-003) that polychlorinated dibenzodioxins (PCDD's) and dibenzofurans (PCDF's) are formed during the chlorination stage in kraft pulp bleaching. These substances are considered highly toxic and bio-accumulative.

When chlorine reacts with lignin, one of the by-products is dioxin which environmentalists and some scientists contend is a threat to human health even in the smallest measurable quantities.

Furthermore, their contention is that dioxin is not the only dangerous by-product of chlorine bleaching; rather, that it is only the most notorious and highly publicized of about 1,000 chemicals emitted by pulp mills.

From dioxins, the chlorine issue progressed to concern over AOX in the effluent and AOX has become a standard parameter for measuring environmental harm. AOX measures the total organochlorines (i.e. chlorinated organic matter) in wastewater and has been widely used as a measure of pulp mill discharges because organochlorines include dioxins and furans.

The North American chlorine debate recently took on new urgency when the US Environmental Protection Agency (EPA) published new proposed effluent guidelines for US mills and two Canadian provinces, BC and Ontario, recently proposed some of the most stringent pulp mill effluent regulations in the world.

The controversy about health effects of chlorine bleaching in North American pulp and paper mills first surfaced in the US in the mid-eighties. The EPA and the American Paper Institute (API; now the American Forest & Paper Assn, AFPA) entered into an extended debate about the dangers of pulp mill dioxins to human life, both as a carcinogen and as a source of reproductive and immune system disorders.

By 1990, the debate was sidestepped by Greenpeace which took a different approach altogether. Greenpeace sought to reduce chlorine bleaching by influencing the marketplace rather than the regulatory environment. It encouraged readers of *Time Magazine* to write letters requesting the magazine to switch to paper bleached without chlorine. In early 1992, *Time Magazine* announced its intention to do so "as soon as it is practical", but this has not yet happened. Similarly, the General Services Administration (GSA) of the United States, which buys about $300 million worth of paper annually for federal government agencies, has been heavily lobbied to include TCF specifications in its purchasing guidelines, but so far these have not been imposed on the industry. Although Greenpeace's initiatives in the North American marketplace have met with limited success because of insufficient supply, there are a variety of regulatory proposals under consideration which would effectively limit chlorine bleaching by the North American pulp and paper industry.

In the US, new air and water emission guidelines proposed by the EPA are of the most immediate concern. In addition, the Clinton Administration, as part of proposed reauthorization of the Clean Water Act, has recommended that the EPA release a strategy for the substitution, reduction, or prohibition of chlorine and chlorinated compounds within two-and-one-half years. The objection to chlorine dioxide usage is that, even though it does not generate as much dioxins as elemental chlorine, it still contains chlorine compounds which may cause biological damage. Greenpeace is lobbying strongly for a complete ban on chlorine (including its compounds) and a new bill, H.R. 2898, the Chlorine Zero Discharge Act of 1993, was introduced in the US Congress last year. It calls for amending the Clean Water Act to completely eliminate discharges of chlorine compounds. It includes a specific section banning the use of any chlorinated bleaching agent in the pulp and paper industry, to prevent the formation of chlorinated organics. A massive, 686 page document, on the subject was released by the EPA in November, 1993. The act, if passed, would phase out use of chlorine and chlorinated compounds in the pulp and paper industry within five years.

In Canada, pulp mills are subject to both federal and provincial emission regulations as shown in Table 4-2. However, there are no federal regulations in place.

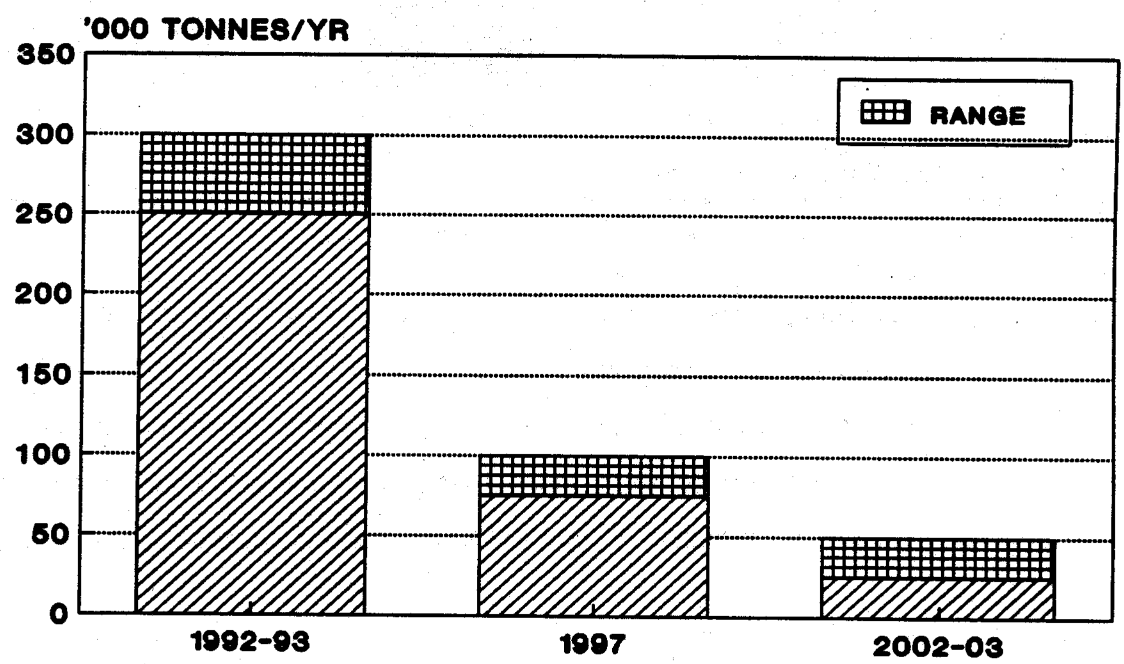
TABLE 4-2
SUMMARY OF CANADIAN PULP MILL EFFLUENT AOX LIMITS
(In kg/MT of pulp)

Ontario	B.C.	PQ
1.5 (Dec 31, 1995) 0.8 (Dec 31, 1999) 0.0 (Dec 31, 2002)	1.5 (Dec 31, 1995) 0.0 (Dec 31, 2000 or 2002)	1.5-2.5 (Dec 31, 1993) 1.0-2.0 (Sept 30, 1995) 0.8 (Dec 31, 2000)

As shown in Table 4-2, by far the most stringent guidelines for dioxin and AOX levels now exist in BC and Ontario. This means that slightly more than half of Canada's roughly 10 million tonnes of chemical pulp capacity is subject to stringent dioxin and AOX regulations. More may follow as other provinces develop their own regulations.

It is fair to say that the pulp and paper industry responded promptly to the technological challenge of identifying alternative bleaching sequences to the traditional chlorine-based ones. One of the earliest, relatively risk-free alternatives was substitution of chlorine dioxide for chlorine in the initial stages of bleaching. Reflecting ongoing changes in kraft pulp bleaching sequences, in response to the above developments, chlorine usage in North America's pulp and paper industry has been declining at about 10% per year during the last few years. Figure 4-7 shows the effect this will have on the Western North American chlorine demand in pulp bleaching.

Figure 4-7
WESTERN NORTH AMERICAN CHLORINE DEMAND
(TONNES/YR; 100% CONCENTRATION)



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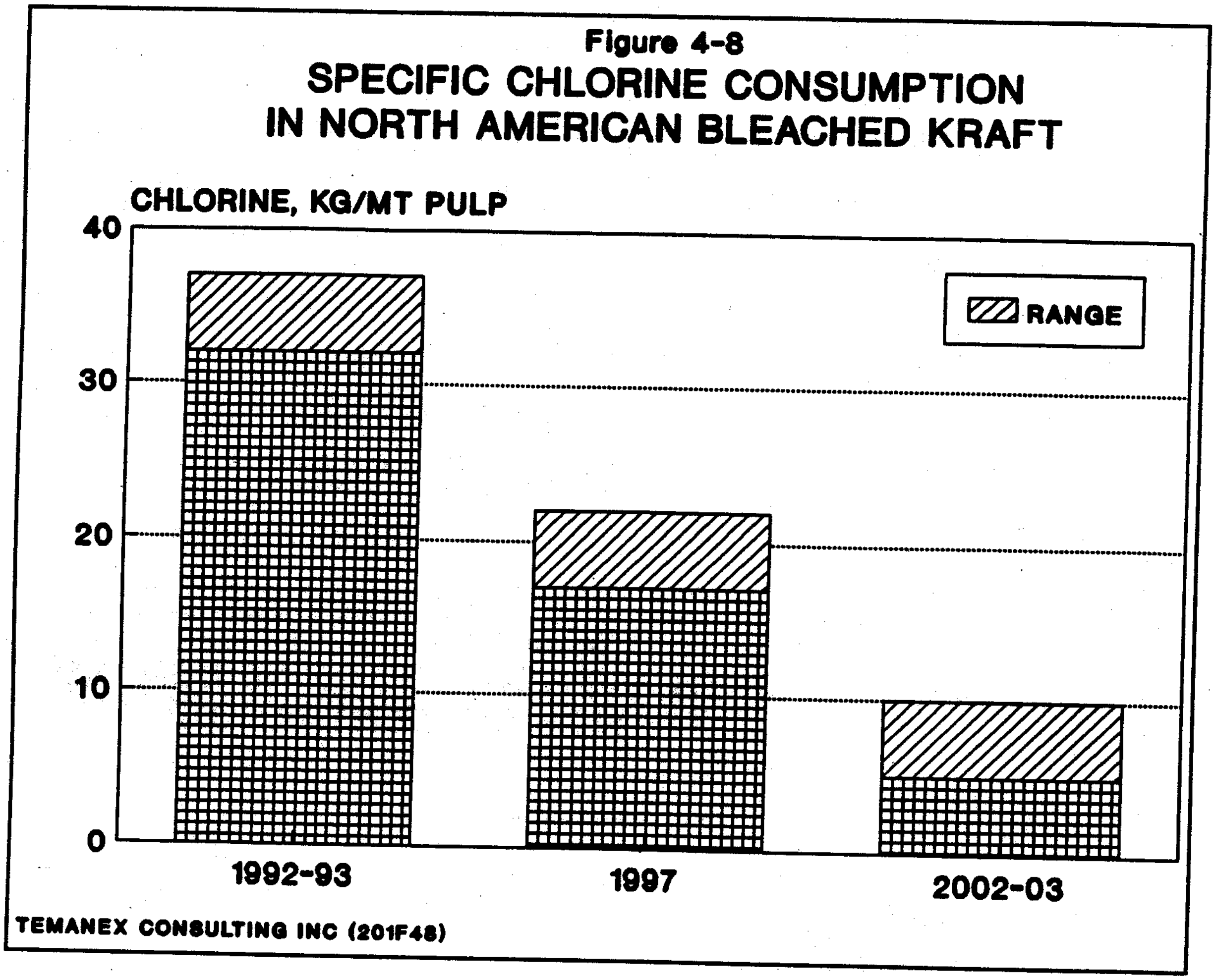
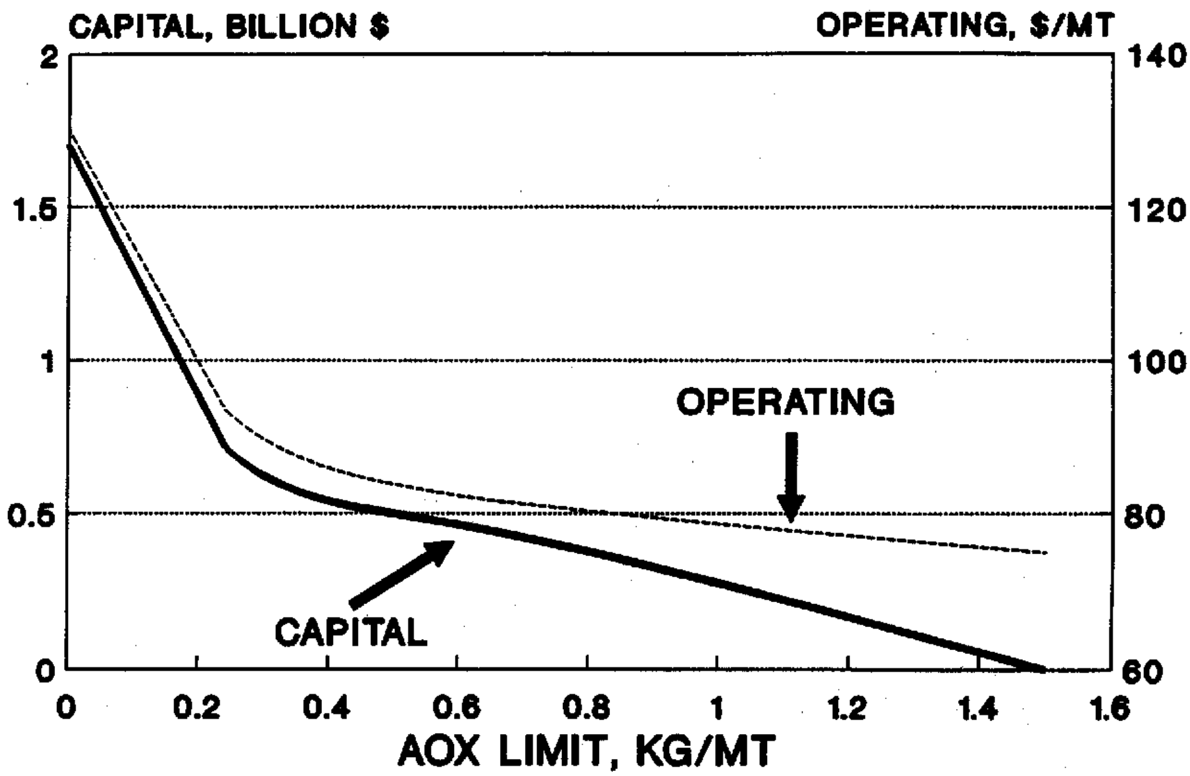
Specific chlorine consumption (per tonne of pulp produced) in North American bleached kraft, currently and in the future years is shown in Figure 4-8, below.



One of the most disturbing effects of the progressive elimination of chlorine bleaching of kraft pulp is the significant capital investment required to implement technology to reduce AOX discharges, as well as a substantial increase in operating costs, primarily due to the need to utilize higher cost bleaching chemicals, such as hydrogen peroxide, admittedly one of the most environmentally friendly compounds. Figure 4-9 summarizes the cost penalties as a function of AOX limit.

Clearly, one of the outcomes of these pressures, at a time when the pulp and paper industry has had a 3-year period of abysmally bad profitability (actually huge financial losses), will likely result in the closure of some of the older, marginal operations. Again, using the MacMillan Bloedel mill at Port Alberni as an example, it should be noted that its kraft pulp plant was recently closed for good for this very reason.

Figure 4-9
WESTERN CANADA BLEACHED KRAFT INDUSTRY
INCREMENTAL COSTS VS. AOX LIMIT



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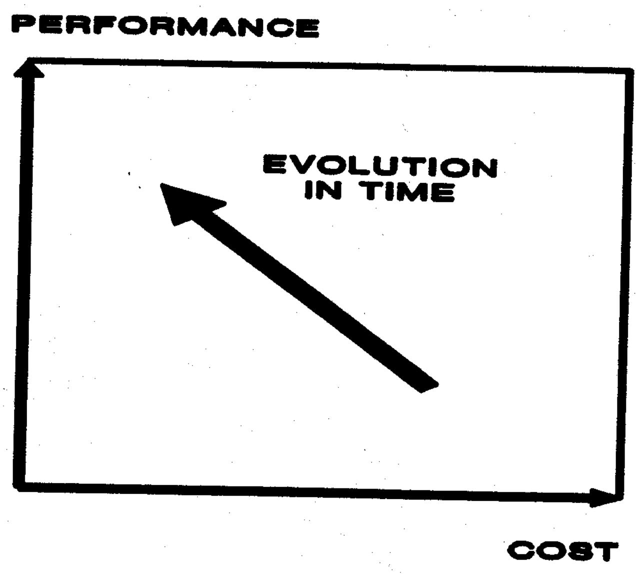
4.2 Market And Technology Issues

In this section non-environment-driven technological developments and trends in papermaking are discussed.

4.2.1 Market And Product Quality Trends

Non-environment-driven technological developments and trends in papermaking are driven by ongoing market demand, and by competitive forces pushing towards higher product quality at a given cost, or equal quality at lower cost. Figure 4-10 depicts these concepts as a higher product performance to cost ratio in time.

Figure 4-10
LONG TERM PERFORMANCE TO COST RATIO FOR PAPER PRODUCTS



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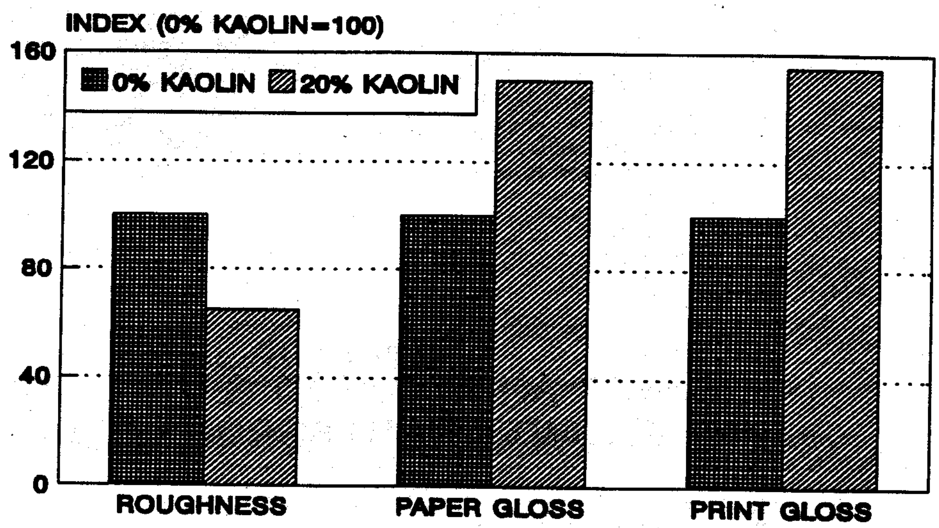
Some of the results of this trend, virtually all of which favour increased utilization of mineral pigments include:

- **Lower paper weight per unit area, i.e. lighter sheets.** This effectively provides greater value for money for the buyer (i.e. more area of paper per tonne of paper), and also reduces postal costs for magazines, catalogues and the like. Evidence for this was already provided in Figure 3-8. Mineral pigments enhance opacity and permit lower sheet weights to be achieved without sacrificing printing performance.

- **Better surface smoothness (lower roughness) and higher gloss.** These paper properties are also of importance in enhancing paper and print quality. For example, gloss is greatly valued by the North American advertiser. Figure 4-11, based on pilot trials carried out by Temanex Consulting on behalf of corporate clients over the last few years, shows the contribution of delaminated kaolin to paper roughness, paper and print gloss.

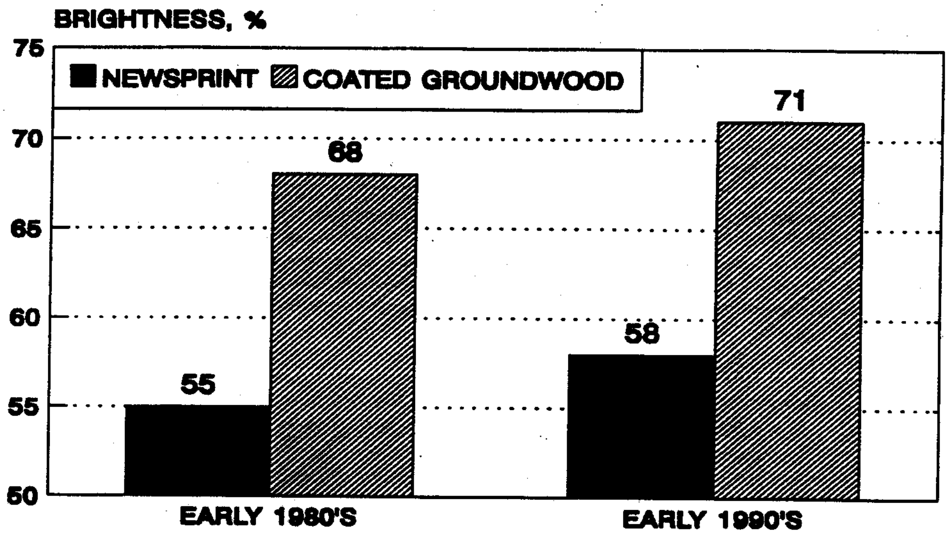
Figure 4-11
CONTRIBUTION OF DELAMINATED KAOLIN TO PAPER ROUGHNESS AND GLOSS



TEMANEX CONSULTING INC (FIG4-11)

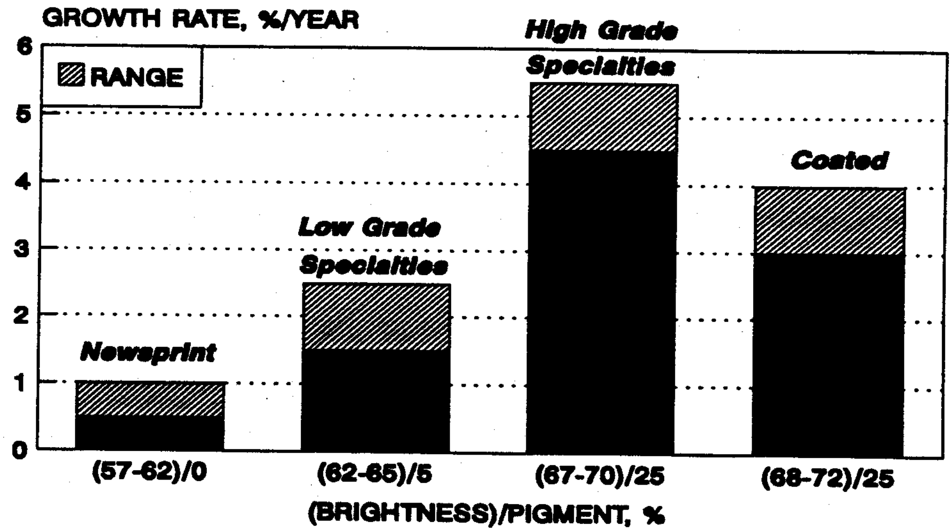
- **Higher paper brightness (whiteness) for a given paper grade and, generally but not always, higher demand growth rates for higher brightness than lower brightness products.** Brightness is possibly the most important quality requirement for printing grades. Higher brightness papers enhance print colour reproduction and overall print quality. Figure 4-12 shows the rather significant increase in newsprint coated groundwood paper brightness between the early 1980's and early 1990's. Furthermore, as Figure 4-13 shows for papers based on mechanical pulp, the highest growth rates are forecast for the higher brightness grades. Again, in addition to opacity enhancement, mineral pigments also enhance brightness.

Figure 4-12
NORTH AMERICAN NEWSPRINT AND COATED GROUNDWOOD BRIGHTNESS TRENDS



TEMANEX CONSULTING INC (FIG4-12)

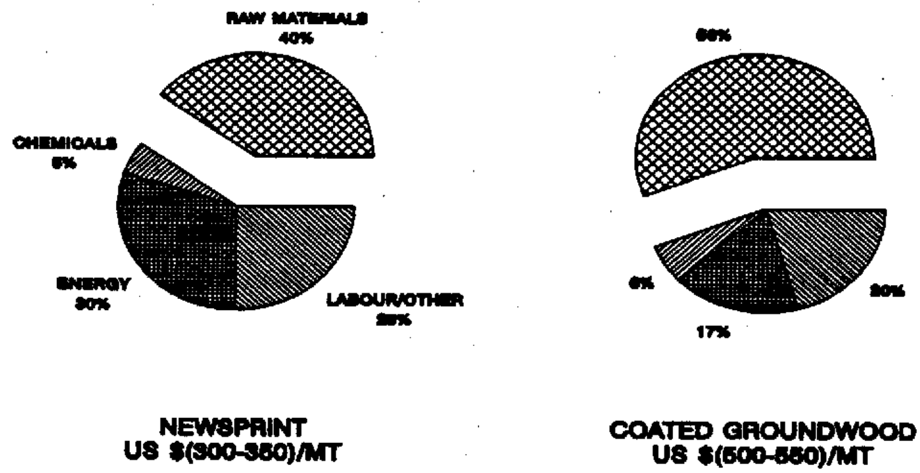
Figure 4-13
UNCOATED AND COATED GROWUNDWOOD PAPER GROWTH RATE FORECAST 1990-2000



TEMANEX CONSULTING INC (FIG4-13)

- **Reduced raw material costs.** Raw material costs (fibre and pigment) generally constitute the largest single cost component in paper manufacture. An example is shown in Figure 4-14, as the breakdown of mill level costs for typical North American newsprint and coated groundwood operations.

Figure 4-14
NEWSPRINT AND COATED GROUNDWOOD PRODUCTION COST BREAKDOWN



TEMANEX CONSULTING INC (FIG4-14)

Clearly, in order to maximize the performance/cost ratio of papers, reducing raw material costs should be given the highest priority. Once again, mineral pigments provide opportunities to achieve this objective. A very important, but subtle point must be appreciated, however, namely that what counts is not the actual pigment cost (i.e. $ per tonne of pigment) but the pigment true cost-effectiveness. For example, if 100 kg of a $500/tonne pigment provide the equivalent opacifying power as 200 kg of $300/tonne fibre, then substitution of fibre by pigment reduces costs by (200/1000)x$300 - (100/1000)x$500 = $10 per unit area of paper produced. A less expensive pigment, say at $400/tonne but only capable of displacing 150 kg of fibre for each 100 kg of pigment, can only provide savings of (150/1000)x$300 - (100x/1000)$400 = $5 per unit area of paper produced. Therefore, even though it is less expensive, it is not as cost-effective as the higher cost pigment, which should be preferred.

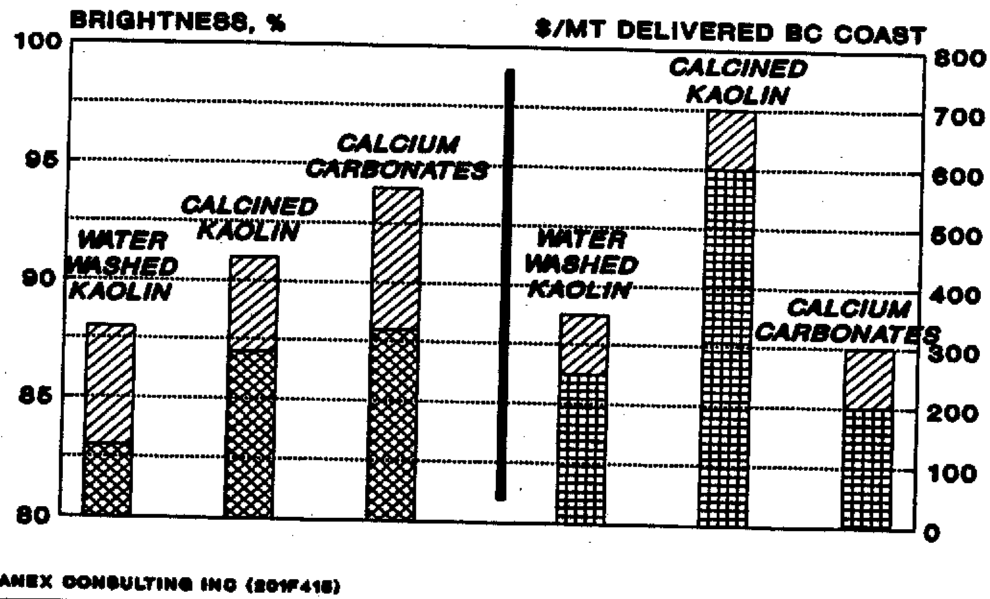
4.2.2 Neutral/Alkaline Papermaking For Mechanical Pulp-Based Papers

The explosive shift to neutral/alkaline papermaking of the fine (woodfree) paper industry in North America was described in chapter 3. The major drivers for this trend were:

- **The need to reduce paper raw material costs.** Calcium carbonate, especially the recently developed precipitated grades, sell as low as US $150/MT, which is considerably lower than fibre whose costs range from US $(200-300)/MT for mechanical pulps to US $(400-800)/MT for chemical pulps, depending on grade and market softness. Alkaline papermaking allows an increase of about 5 percentage points in paper pigment content (e.g. from 15% to 20% of sheet weight) without compromising paper strength.

- **Calcium carbonates generally have a higher brightness than kaolin grades, yet at a lower delivered cost in general.** This is shown in Figure 4-15.

Figure 4-15
BRIGHTNESS AND COST OF PAPERMAKING PIGMENTS



- **Neutral/alkaline papers have a much greater longevity than acid papers.** This is important for archival properties and strongly lobbied for by The National Library in

Ottawa and the US Library Of Congress.

One of the concerns with neutral/alkaline papermaking is a more challenging papermaking chemicals control system, which in the early stages of a conversion from acid to alkaline may cause significant quality and efficiency losses. This has now been effectively overcome.

The main problem in switching groundwood (more correctly mechanical pulp) papers to neutral/alkaline conditions, is that lignin in mechanical pulps turns yellow under alkaline conditions, resulting in unacceptable loss of brightness. Unfortunately, neutral or alkaline conditions are necessary when calcium carbonate is utilized, since calcium carbonate goes into solution under acid conditions. This, traditionally, has effectively precluded the use of calcium carbonates in groundwood papers.

However, early efforts in Europe are beginning to pay off, in particular in the coated groundwood area. Furthermore, a strong technical effort is underway by the major calcium carbonate suppliers, to penetrate the very large groundwood papers market (about 25 million tonnes of production per year in North America). One of the approaches is AT (Acid Tolerant) technology, promoted by the largest precipitated calcium carbonate supplier, Specialty Minerals, from Bethlehem, Pennsylvania. The principle of this technology is to "coat" each calcium carbonate particle with a protective layer, making it possible to incorporate these particles under mildly acid conditions (pH of 6.5 to 7). Although it will be another 5-10 years, we estimate, before this technology becomes more widespread, there are early opportunities even in B.C. According to recent field intelligence, a West Coast newsprint and groundwood specialties mill is, or will be shortly, running trials with calcium carbonate imported from Denmark.

4.3 Papermaking Mineral Pigments Quality

The physicochemical properties of mineral pigments determine their potential for utilization in paper filling and coating. The primary physicochemical properties of mineral pigments commonly used in papermaking are summarized in Table 4-3.

TABLE 4-3

PROPERTIES OF SOME MINERAL FILLERS

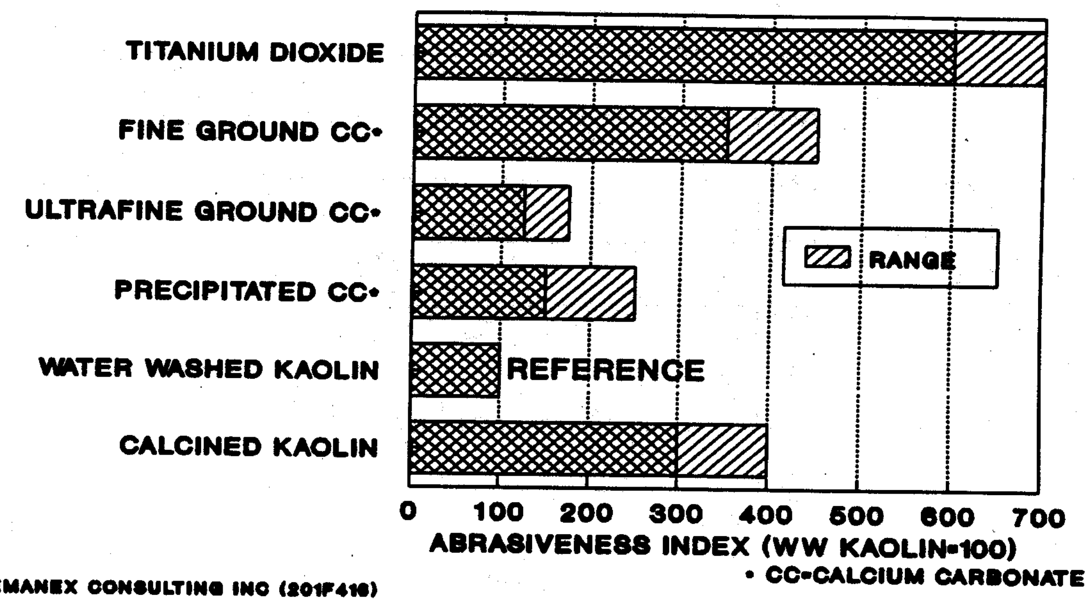
	Theoretical Chemical Composition	Specific Gravity	Bulk Density, LB per Cu Ft	Hardness, Mohs Scale	Refractive Index	Reaction pH	Oil Absorption, Cc,/100 G	Particle Characteristics
Kaolin	$Al_20_3 \cdot 2Si0_2 \cdot 2H_20$	2.6	20-40	2.0-2.5	1.56-1.58	4.5-7	25-50	Thin, flat hexagonal plates, 0.05-2μ size and stacks of same.
Limestone	$CaC0_3$	2.7	40-60	3	1.63-1.66	7.8-8.5	12-30	Variable size particles; ultimate rhombs.
Silicas, crystalline	$Si0_2$	2.60-2.65	50-80	6.5-7.0	1.53-1.54	6-7	20-50	Variable sized, angular and equi-dimensional particles.
Slate	Mixture of mineral silicates	2.7-2.8	40-80	4-6	-	6.8	20-25	Flat or wedge-shaped, or spherical grains.
Titanium Dioxide	$Ti0_2$	3.9-4.2	-	5-7	2.55-2.7	-	-	0.2-0.3μ, largely spherical shaped particles.

See Appendix 2 for physical properties of prominent commercial papermaking pigments

Papermaking mineral pigments are selected according to their cost-effectiveness, which is based on performance as filler or coating pigments. The performance priorities will vary by paper grade. For example, photocopy grades (uncoated woodfree) have opacity, brightness and bulk preservation at a high level of priority, while paper or print gloss are not really required. Therefore, "blocky" type pigments, such as precipitated calcium carbonate, are preferred to "platey" pigments such as water-washed kaolin. The latter, however find significant applications in print advertising papers, such as those used for magazines and catalogues. Therefore, defining universal quality targets for papermaking mineral pigments, applicable to all pigments and their paper end uses, is not meaningful, or possible. There are, however, some general requirements for papermaking pigments, specifically:

- **Low abrasiveness.** Figure 4-16 shows a comparison of abrasiveness of various major papermaking pigments.

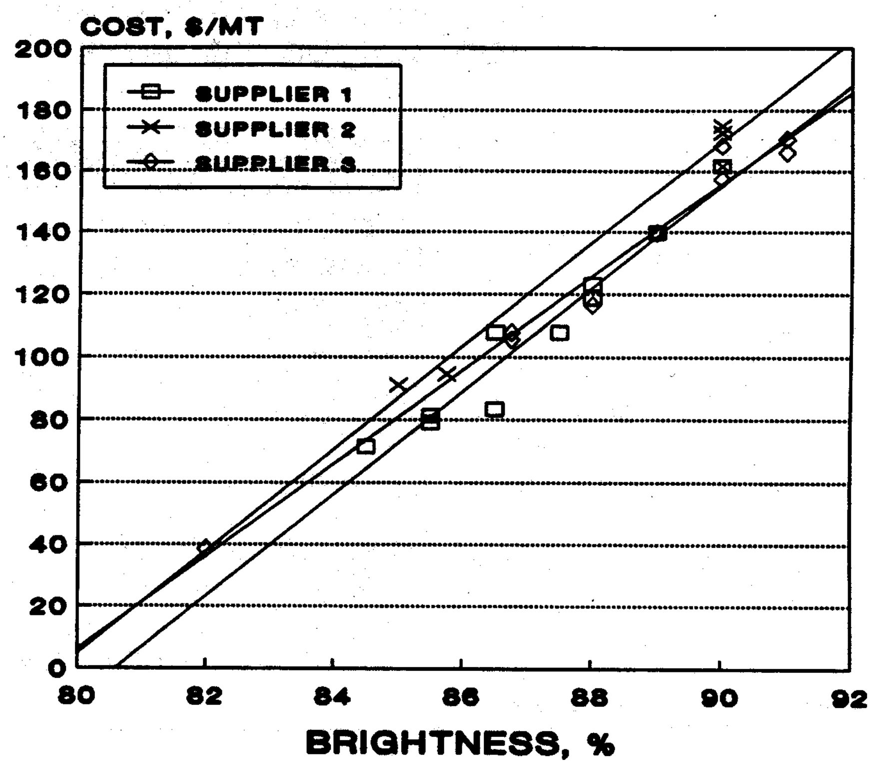
Figure 4-16
EINLEHNER ABRASIVENESS FOR VARIOUS PIGMENTS



Paper machines are expensive pieces of equipment. A single, modern machine nowadays costs about $200 million installed. Furthermore, consumables on the paper machine, which include dewatering screens, fabrics and rotating rolls are also expensive. The dewatering fabric screens cost about $50,000-$100,000 each. Abrasive pigments reduce the lifetime of these mechanical consumables and of other, costlier paper machine components, and papermakers are averse to using them. Abrasiveness depends on pigment type, processing and the presence of impurities. The most prevalent, standard abrasiveness test is now the Einlehner wire (drainage fabric screen) abrasion test.

- **High brightness.** This is the most desirable universal property of papermaking mineral pigments. Within a given pigment type, there is a close relation between brightness and pigment price, as seen in Figure 4-17 (this, however, does not apply when comparing different pigments - as already seen in Figure 4-15).

Figure 4-17
WATER WASHED KAOLIN FOB COST
AS A FUNCTION OF BRIGHTNESS



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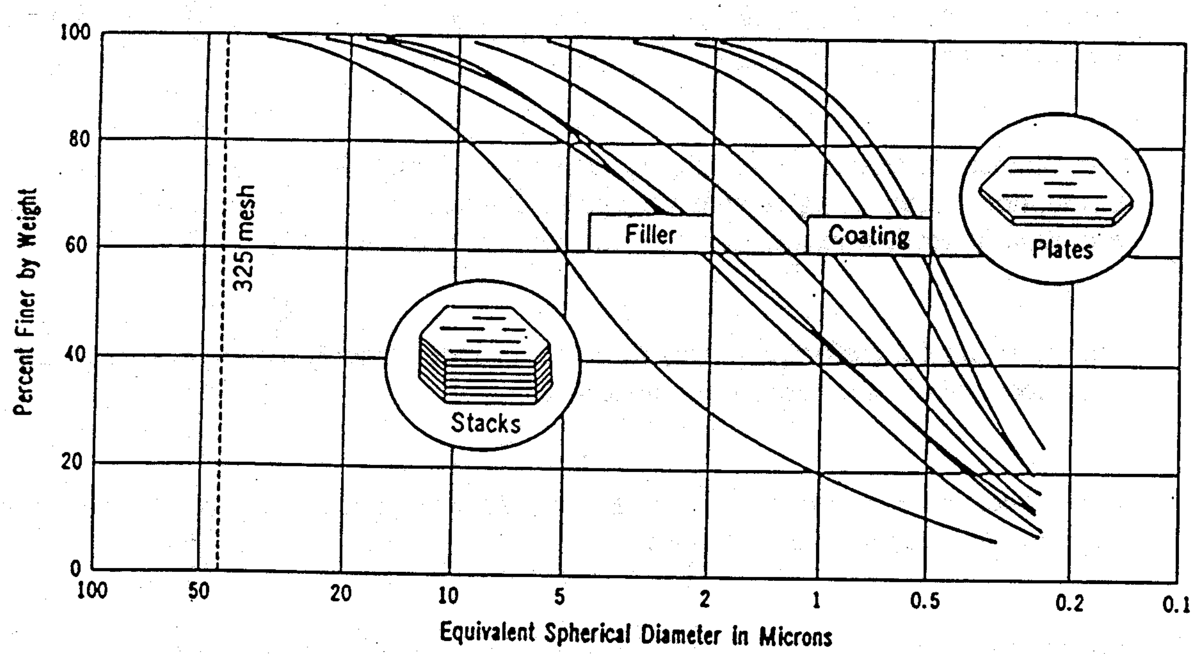
- **Particle size distribution.** This is the last universal property of pigments. Again it varies by pigment but, typically, it is in the 0.5-2 micron range, see Figure 4-18. The finer the pigment particle size distribution the greater the pigment light scattering (brightening and opacifying power) potential and the lower the abrasiveness is, in general. However, pigment particle size cannot be made too fine for two reasons:

  - It will have poor retention in the paper sheet during the papermaking operation; and

  - At some point, extra fine particle sizes approaching the wavelength of light (400 to 700 nanometres) become ineffective in light scattering, since light rays "cannot see them".

Figure 4-18

PARTICLE SIZE DISTRIBUTION - FILLER AND COATING CLAYS



5.0 Paper And Pigment Forecast

5.1 British Columbia Paper And Pigment Forecast - 1993 To 2003

Table 5-1 contains the Temanex Consulting tonnage forecast for different paper products and the corresponding pigment demand for these papers. The following should be noted in using this table:

- The paper forecast shows a significant restructuring of the B.C. paper industry away from newsprint and towards higher value, pigmented papers (in particular uncoated and coated groundwood).

- The small amount of pigment used in newsprint reflects new/purchased pigment going into special orders for customers demanding special qualities achieved with specialty pigments. It does not include recycled pigment from deinking coated magazine grades, which does not represent a market opportunity.

- Talc used for pitch control in pulp and deinking mills is not included as part of the papermaking pigments tonnage (the talc tonnages were estimated and forecast in a recent Temanex report for Supply & Services Canada, TN-94-198 "Update Of A Market Study For Talc", February 1994).

- The pigment forecasts for Uncoated Groundwood and Woodfree papers include an assumption of increasing percentage pigment content in these papers. This is a natural evolution of product quality and pigment utilization technology.

- The paper (and therefore pigment) forecasts include some cyclicality, as projected by large econometric and forecasting think tanks.

- The "Other Papers" category shows a small amount of mineral pigment used in one recycled paperboard coating operation.

- Not all pigments used in coating operations are the higher (than filler grade) quality, coating grade pigments. Approximately 5% by weight of pigment is filler grade product used to optimize cost-effectiveness.

TABLE 5-1

BC PAPER & PAPER PIGMENT FORECASTS - 1993 TO 2003

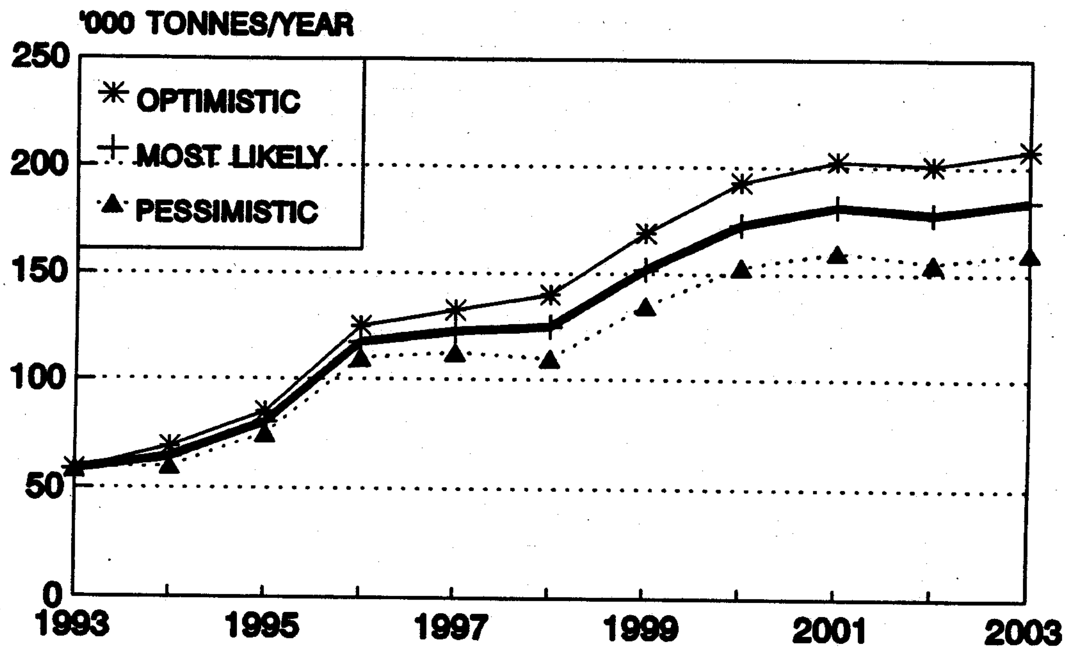
PRODUCT	1993 000 MT/YR	1994 000 MT/YR	1995 000 MT/YR	1996 000 MT/YR	1997 000 MT/YR	1998 000 MT/YR	1999 000 MT/YR	2000 000 MT/YR	2001 000 MT/YR	2002 000 MT/YR	2003 000 MT/YR
NEWSPRINT	1500	1550	1450	1450	1400	1350	1400	1250	1200	1100	1150
NEWSPRINT PIGMENT	1	1.15	1.3	1.5	1.65	1.75	2	2	2	1.9	2
UGWD	420	450	550	550	575	550	550	575	600	550	575
UGWD PIGMENT	21	25	33	33	37	39	44	46	54	50	56
CGWD	0	0	25	150	150	150	225	300	300	300	300
CGWD PIGMENT	0	0	7	41	41	41	62	83	83	83	83
UWF	50	47	45	40	40	40	40	40	40	40	40
UWF PIGMENT	7	6.58	6.75	6	6	6	6.4	6.4	6.4	6.4	6.4
CWF	75	83	85	95	97	100	100	95	97	100	97
CWF PIGMENT	22.5	24.9	25.5	28.5	29.1	30	30	28.5	29.1	30	29.1
OTHER PAPERS	720	760	785	815	835	765	815	840	840	785	760
OTHER PIGMENT	7	7	7	7.25	7.25	7.5	7.5	7.5	7.5	7.75	7.75
TOTAL PIGMENT(000MT/YR)	**59**	**64**	**80**	**118**	**123**	**125**	**152**	**173**	**182**	**178**	**184**

NOTE: TYPE AND ALTERNATIVE PIGMENT OPTIONS ARE PROVIDED in Figure 5-2 and Table 5-2

Temanex Consulting Inc. (Table5-1)

The forecast for papermaking mineral pigments is seen to be quite bullish over the forecasting period, with consumption projected to increase from about 59,000 tonnes in 1993 to 184,000 tonnes in the year 2003, a 12% per year compound growth rate, far greater than the 0.5-1% per year for overall paper and paperboard production growth. Figure 5-1 shows the most likely, pessimistic and optimistic forecasts for papermaking mineral pigments demand by the B.C. pulp and paper industry.

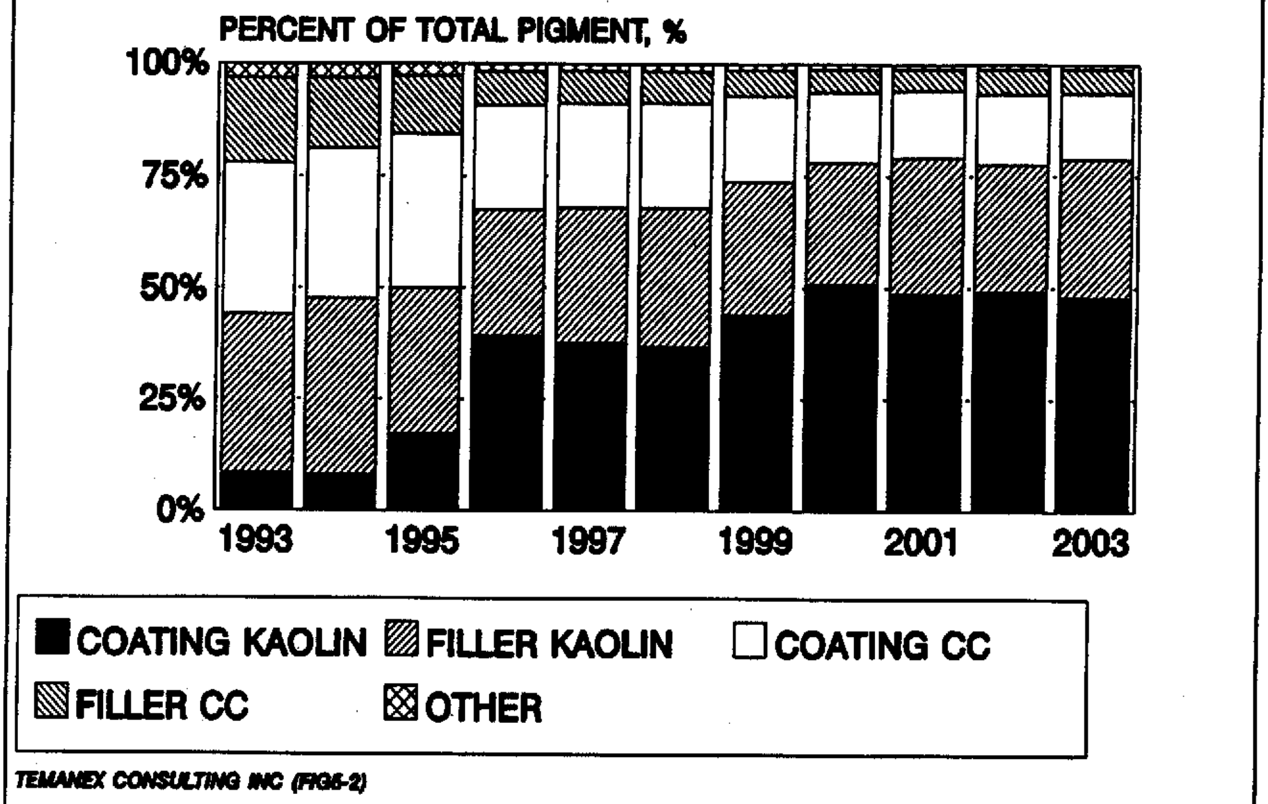
Figure 5-1
MOST LIKELY, OPTIMISTIC & PESSIMISTIC PAPER PIGMENT FORECASTS FOR BC



TEMANEX CONSULTING INC (FIG5-1)

With regard to changes in the B.C. pigment market structure over the forecast period, the most significant will be a reduction in the woodfree paper share (this is mostly calcium carbonate) and an increase in the coating pigments share [see page 55 this chapter], as shown in Figure 5-2.

Figure 5-2
MOST LIKELY PIGMENT TYPES AND SHARES IN BC



5.2 Paper And Pigment Forecast For All Western North America In 2003

Table 5-2 summarizes 1993 estimates and 2003 forecast for papermaking mineral pigments for all of Western North American provinces and states with papermaking capacity, namely Alberta, Saskatchewan and B.C. in Canada, and Washington, Oregon, California, Idaho and Arizona in the USA. Again, pigments demand growth over this 10-year period will be quite healthy, at about 10% per year, or roughly four times as large as the forecast growth in paper production.

TABLE 5-2
PAPER PRODUCTION AND PIGMENT DEMAND
IN WESTERN NORTH AMERICA

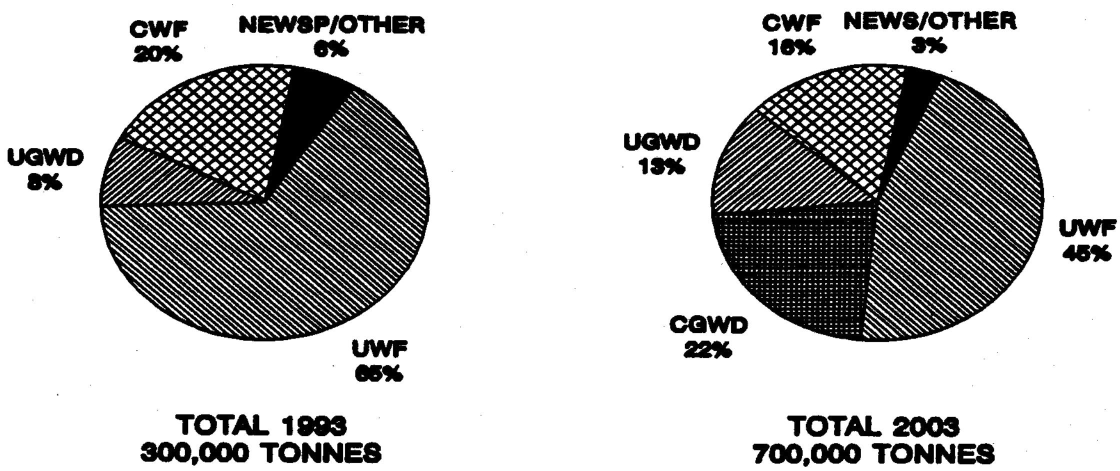
PRODUCT	1993 (000 MT/YR	2003 (000 MT/YR)	Typical Pigment	Alternative
NEWSPRINT NEWSPRINT PIGMENT	3700 4	4000 6	Alumino Silicates	Calcined Kaolin
UGW UGW PIGMENT	850 25	1200 100	Calcined/ Filler Kaolin	None*
CGWD CGWD PIGMENT	0 0	600 165	Coating Kaolin	Kaolin & GCC
UWF UWF PIGMENT	1400 296	2100 339	PCC	None+
CWF CWF PIGMENT	200 60	400 120	GCC, Coating Kaolin	Future PCC?
OTHER PAPER PIGMENT	15	20	All	All
TOTAL PIGMENT	**300**	**750**		

* Calcium Carbonate trials are underway
+ Used to be filler Kaolin

Figure 5-3 summarizes the 1993 and 2003 breakdown of papermaking mineral pigments by end use, again showing that the share of pigments in coated paper applications will increase at the expense of uncoated end uses.

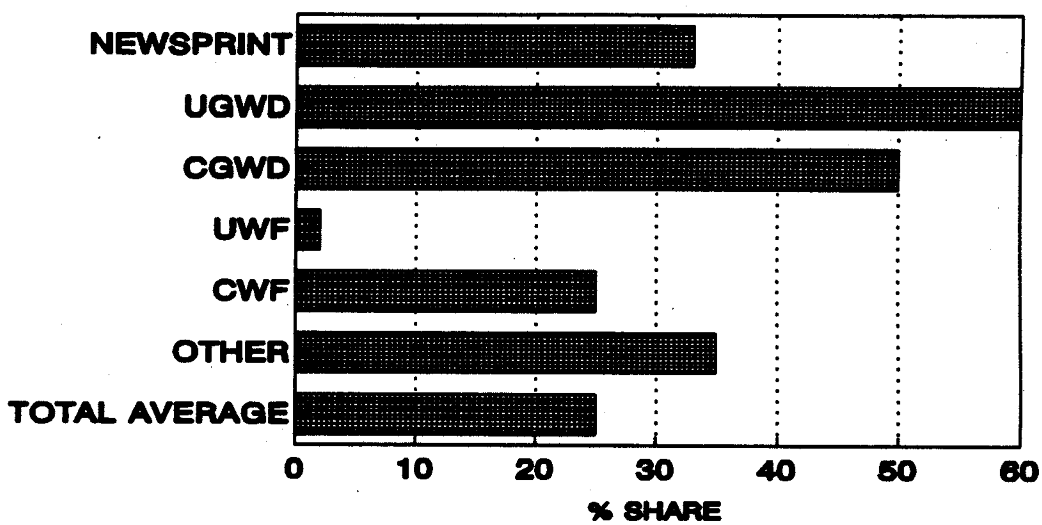
Finally, Figure 5-4 shows the B.C. paper industry's share of total North American papermaking mineral pigments demand in the year 2003. With the exception of the large uncoated woodfree (UWF) sector, where B.C.'s share is expected to remain quite small, the province will have a significant share position in papermaking mineral pigments demand.

Figure 5-3
TOTAL WESTERN NORTH AMERICAN PAPER MINERAL PIGMENTS FORECAST



TEMANEX CONSULTING INC (FIG5-3)

Figure 5-4
2003 BC PAPER INDUSTRY SHARE OF W. NORTH AMERICAN PAPERMAKING MINERAL PIGMENTS



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APPENDIX 1

BASIC TERMINOLOGY

APPENDIX 1

BASIC TERMINOLOGY

AAC - Annual Allowable Cut (annual volume of timber which it is permissible to remove to ensure long term availability).

ADMT - Air dry metric tonne - normally pulp at 10% moisture content.

BASIS WEIGHT - Weight per unit area of paper, usually expressed in grams per square meter (gsm), or lbs. per 3000 or 3300 square feet.

BCTMP - Bleached chemi-thermomechanical pulp.

BDMT - Bone dry metric tonne (i.e. excluding moisture).

BHKP - Bleached hardwood kraft pulp.

BSKP - Bleached softwood kraft pulp.

BOARD - Also known as **Paperboard**, refers to heavy packaging paper grades.

CHEMICAL PULP - Woodpulp produced by chemical digestion of wood chips to separate wood fibres. It is the strongest and brightest (when bleached) pulp, but also the most expensive.

CGW - (CGWD) - Coated Groundwood Paper.

CWF - Coated Woodfree Paper.

COATED GRADES - Paper grades to which a mineral pigment coating has been applied to enhance appearance and surface properties for printing:

- **Coated Mechanical** or **Coated Groundwood** refers to papers containing significant amounts of Mechanical Pulp (see below);
- **Coated Woodfree** or **Coated Fine** refers to papers containing 0%-10% Mechanical Pulp and 90%-100% Chemical Pulp (see above) as the fibre (e.g. excluding the pigment) component. The U.S. classification defines "coated grades" in classes from No. 1 to No. 5; No. 1 being the highest quality and No. 5 being the lowest.

CTMP - Chemithermomechanical Pulp - a mechanical pulp made from wood chips in large, pressurized refiners (- see TMP).

COMMUNICATION PAPERS - Paper grades, generally lightweight, which are used to store and transmit information in printed form (Newsprint, Fine, Coated, etc.).

FBK - Fully Bleached Kraft Pulp.

FINE PAPERS - Also known as WOODFREE, these grades contain less than 10% by weight of mechanical pulp in the fibre component (i.e. excluding pigments) of their papermaking furnish.

FURNISH - Also referred to as PAPERMAKING FURNISH, this is the mix of materials (fibers, pigments, binders) which makes up the raw material for making paper.

GWD - Groundwood.

GROUNDWOOD The most prevalent Mechanical Pulp.

GSM - Grams per Square Meter, units for Basis Weight (see above).

LIGHTWEIGHT COATED (LWC) - A Coated Mechanical printing grade consisting roughly of 1/3 Pigment, 1/3 Chemical and 1/3 Mechanical Pulp by Weight, of basis weight up to about 65 or 72 GSM (see above), depending on definition. In the U.S., this is also known as **Coated No. 5 grade.**

MECHANICAL PULP A pulp produced by mechanical comminution of wood into its elemental building blocks, fibres.

MT - Metric Tonne.

NEWS - Newsprint.

PCC - Precipitated Calcium Carbonate.

P&W - **(Printing & Writing)** - Papers used to store and transmit information in printed form, excluding Newsprint.

SBK - Semibleached Kraft Pulp.

SKP - Softwood Kraft Pulp.

SGW	-	Stone Groundwood, a pulp made by grinding wood against an abrasive stone.
SC	-	**(Supercalendered)** - A term loosely defining heavily filled (to 30% by sheet weight) Mechanical (Pulp) papers which are finished to a smooth, glossy surface on a "supercalender", a device which "irons" paper after the paper machine. Almost all Coated Mechanical and most Coated Woodfree is also supercalendered to develop desirable surface properties.
TMP	-	Thermomechanical pulp - mechanical pulp made from wood chips in large, pressurized refiners (-see CTMP).
TONNES	-	Metric tons (1000 kg), the primary weight unit used in this report. *To change from short tons to tonnes, divide by 1.102.*
UBK	-	Unbleached Kraft Pulp.
UGWD	-	(UGW) - Uncoated Groundwood Paper (e.g. for inserts).
UWF	-	Uncoated Woodfree Paper (e.g. for photocopies).
WOODFREE		A paper made with Chemical Pulp as its fibre component; it may contain up to 10-15% Mechanical Pulp.

APPENDIX 2

TYPICAL PROPERTIES OF ENGELHARD HIGH PERFORMANCE KAOLIN-BASED PIGMENTS AND ADDITIVES

Typical properties of Engelhard high performance kaolin-based pigments and additives.

Engelhard paper pigments are white, insoluble, inert, water-washed kaolins. They have been specially processed to remove hard particles and other foreign contaminants. These grades are available in dry powder form or as high solids dispersions in water.

	PARTICLE SIZE % FINER THAN 2μm	TAPPI BRIGHTNESS (%)	RESIDUE +325 MESH (% MAX)	pH	BROOKFIELD VISCOSITY (cps)	SPRAY DRIED MOISTURE (% max)	SLURRY SOLIDS (%)
ANHYDROUS GRADES							
ANSILEX 93®	86-90	92.5-93.5 (2)	0.015	5.5-6.5	100-400 (7)	1.0	49-52
ANSILEX®	86-90	90.0-92.0 (1)	0.015	5.5-6.5	100-400 (7)	1.0	49-52
HI-OPAQUE®	65-75	85.5-88.0	0.03	5.5-6.5	— (9)	1.0	—
SPECTRAFIL™	78-84	80.0-82.0	0.03	5.5-6.5	— (9)	1.0	—
COATING GRADES							
EXSILON®	N.A.	86.0-87.0 (1)	0.01	6.0-8.0	50-200 (8)	1.0	61.5-62.5
ULTRA GLOSS 90®	96-100	90.0-92.0 (1)	0.01	6.0-8.0	200-400 (5)	1.0	69.5-70.5
ULTRA WHITE 90®	90-94	90.0-92.0 (1)	0.01	6.0-8.0	250-350 (5)	1.0	69.5-70.5
LUSTRA®	90-94	86.5-87.5 (1)	0.01	6.0-8.0	250-350 (5)	1.0	69.5-70.5
ULTRA COTE®	78-82	90.0-92.0 (1)	0.01	6.0-8.0	200-300 (5)	1.0	69.5-70.5
HT™	78-84	85.5-86.5 (1)	0.01	6.0-8.0	200-300 (5)	1.0	69.5-70.5
GORDON®	68-74	83.0-86.0 (1)	0.04	6.0-8.0	350-450 (5)	1.0	69.5-70.5
S-23™	63-69	84.5-85.5 (1)	0.04	6.0-8.0	250-350 (5)	1.0	69.5-70.5
DELAMINATED GRADES							
NUFIL 90™	N.A.	89.0-91.0	0.01	6.0-8.0	600-800 (4)	1.0	65-67
NUFIL™	N.A.	87.5-89.0 (1)	0.01	6.0-8.0	250-500 (6)	1.0	67-69
NUSHEEN®	N.A.	87.5-89.0 (1)	0.01	6.0-8.0	400-600 (3)	1.0	69-70
NUCLAY®	N.A.	87.5-89.0 (1)	0.01	6.0-8.0	250-500 (6)	1.0	67-69
FILLER GRADES							
COLUMBIA®	78-84	85.0-86.5 (1)	0.01	6.0-8.0	250-350 (5)	1.0	69.5-70.5
KWW™	55-65	83.0-84.0 (1)	0.15	6.0-8.0	300-500 (5)	—	69.5-70.5
KWW™ PULVERIZED	55-65	83.0-84.0	0.15	3.5-4.5	— (9)	1.0	—
MCS™	45-60	82.0-83.0	0.15	6.0-8.0	— (9)	1.0	—
MCS™ PULVERIZED	45-60	82.0-83.0	0.15	3.5-4.5	— (9)	1.0	—

All properties measured as Predispersed Spray Dried except where noted.
(1) As slurry, properties representative of dry kaolin content
(2) As slurry, 0.5 lower Brightness
(3) 69% Solids, No. 2 Spindle 20 RPM, Slurries as Shipped
(4) 65% Solids, No. 2 Spindle 20 RPM, Slurries as Shipped
(5) 70% Solids, No. 1 Spindle 20 RPM, Slurries as Shipped
(6) 67% Solids, No. 1 Spindle 20 RPM, Slurries as Shipped
(7) 50% Solids, No. 1 Spindle 20 RPM, Slurries as Shipped
(8) 62% Solids, No. 1 Spindle 20 RPM, Slurries as Shipped
(9) Not available in slurry

Slurries at 69.5%-70.5% Solids:
Weight of Slurry 14.4-14.7 lbs./gal.
Dry Kaolin Content 9.9-10.4 lbs./gal.

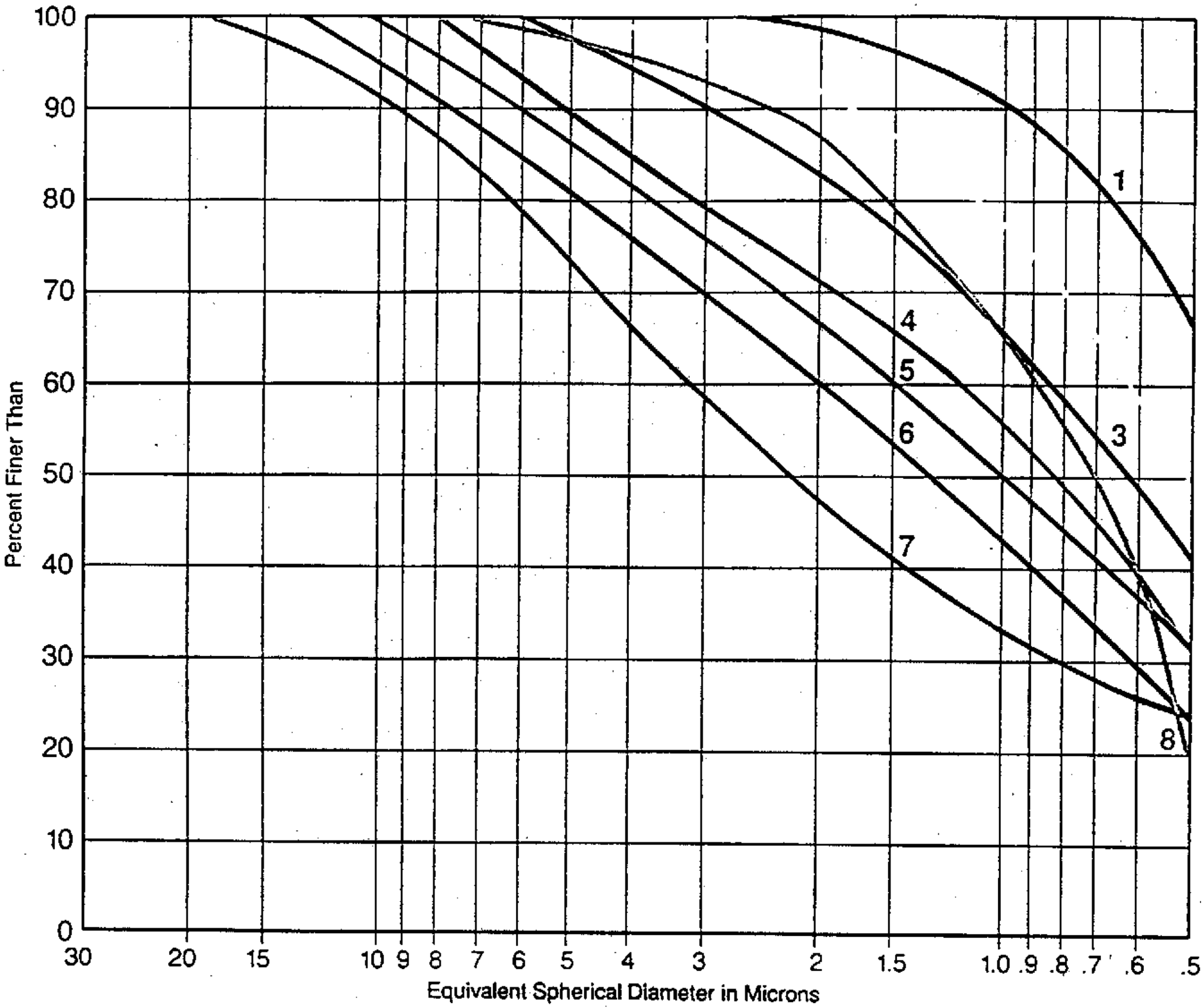
Slurries at 62.0% Solids:
Weight of Slurry 13.4 lbs./gal.
Dry Kaolin Content 8.33 lbs./gal.

ANSILEX® and ANSILEX 93®
Slurries at 49-52% Solids
Weight of Slurry 12.1-12.4 lbs./gal.
Dry Kaolin Content 5.9-6.5 lbs./gal.

Bulking Requirements:
Spray Dried Kaolins
45-50 lbs/cu. ft.
Anhydrous
20-25 lbs/cu. ft.

Typical Properties (continued)

Typical particle size distributions



1 ULTRA GLOSS 90®
ULTRA WHITE 90®, LUSTRA®
3 ULTRA COTE®, HT®, COLUMBIA®
4 GORDON®
5 S-23™
6 KLONDYKE™
7 MCS™
8 ANSILEX®, ANSILEX 93®

Physical constants

Refractive Index –
- Hydrous Kaolins 1.56
- Anhydrous Kaolins 1.62

Specific Gravity –
- Hydrous Kaolins 2.58
- Anhydrous Kaolins 2.70

Typical chemical analysis

Silica (SiO_2)	45.42%
Aluminum (Al_2O_3)	38.79%
Loss on Ignition	13.79%
Titanium (TiO_2)*	1.59%
Calcium (CaO)	0.35%
Iron (Fe_2O_3)	0.42%
Sodium (Na_2O)	0.13%
Potassium (K_2O)	0.12%

(The values given are the average for typical non-floated kaolin samples. Ultraflotation reduces TiO_2 to less than 1%).

Faxe Kalk

Product Specifications

DS/ISO 9001
DS
DS/EN 29001

Faxe Chalk 86

Characteristics

Faxe Chalk 86 has a brightness of 86% (R457) and a natural fine and narrow particle size distribution. The product as crumbles or as slurry is excellent as a paper filler.

Production

Faxe Chalk 86 is manufactured from raw chalk at our plant at Stevns, Denmark, where the raw chalk is excavated from one of the largest and purest deposits of calcium carbonate in Europe.

After washing and screening the brightness is increased by special treatment. Subsequently the water content of Faxe Chalk 86 is reduced by pressure filtration. The product is crushed into crumbles and is supplied either in bulk or as slurry.

Data

Chalk is a natural product and minor variations in properties may occur. The specifications of chemical and physical properties are shown below as average values $\bar{x}$ with standard deviations given as s.

Average values +/- standard deviations multiplied by two ($\bar{x}$ +/- 2·s) indicate the confidence intervals within which 95% of all analysis results are found.

Chemical Analysis

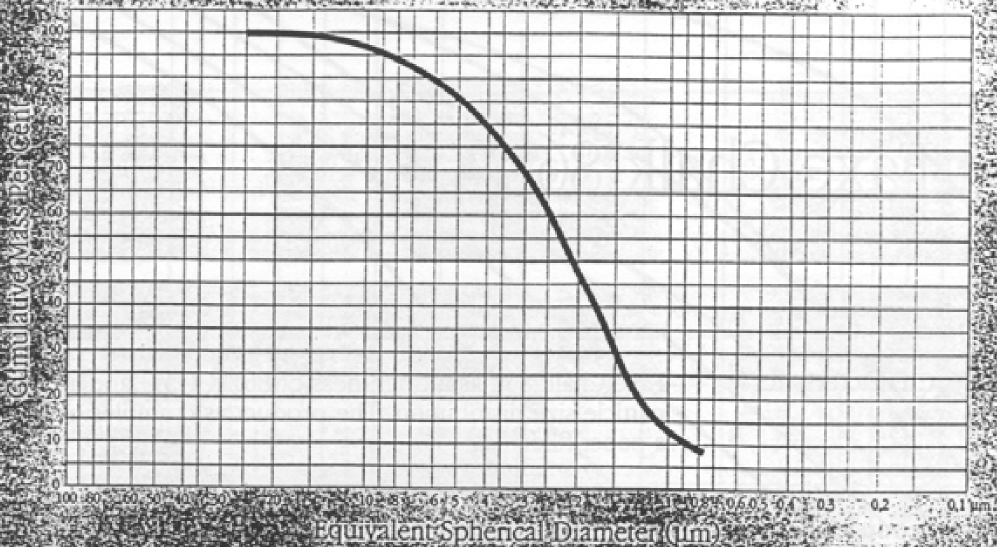
Determined on dry material:		$\bar{x}$	s
Content of Carbonate *)	($CaCO_3$+$MgCO_3$)	98.8%	0.4%
Calcium Carbonate	($CaCO_3$)	97.9%	0.4%
Magnesium Carbonate	($MgCO_3$)	0.70%	0.1%
Silicon Oxide	(SiO_2)	0.35%	0.15%
Aluminium Oxide	(Al_2O_3)	0.10%	0.05%
Ferric Oxide	(Fe_2O_3)	0.04%	0.02%
Manganese Oxide	(MnO)	0.01%	0.00%
Potassium Oxide	(K_2O)	0.04%	0.01%
Phosphorus Pentaoxide	(P_2O_5)	0.12%	0.02%
Sulphur	(S)	0.02%	0.01%
Chloride	(Cl^-)	0.015%	0.005%
Difference		0.70%	
		100.0%	

*) Determined by titration, calculated as $CaCO_3$

Fineness

Ex works values:	$\bar{x}$	s
Sieve residue at 20µm (wet sieving)	0.5%	0.1%
Sieve residue at 45µm (wet sieving)	0.0005%	0.0005%

Particle Size Distribution



Specific Surface 2.2 m²/g according to DIN 66132 (BET)

Density 2.7 g/cm³

		$\bar{x}$	s
Brightness	Determined on ElrephoMat according to DIN 5033 - FMY/A	90.2%	0.5%
	- R457	85.7%	0.5%
Abrasion	Einlehner VWB$_{120}$	23 g/m²	3 g/m²
	Schödel Test - weight loss	1.5 g	0.3 g
	- thickness loss	25 µm	4 µm
Conductivity	According to ISO 787/9	160 µS/cm	30 µS/cm
pH-value	10 g chalk in 90 ml H_2O	8.5	0.3

CRUMBLES

Solids Content Faxe Chalk 86 is supplied as crumbles with a solids content of approx. 84%.

Bulk Density For 84% solids content $\bar{x}$ = 1200 kg/m³ and s = 50 kg/m³

Delivery Crumbles are delivered in bulk.

Storage In ordinary warehouses.

SLURRY

Solids Content Faxe Chalk 86 is delivered as slurry with a solids content of approx. 70%. Other solids contents can be supplied as per arrangement.

Dispersing Agent Slurry can be supplied with or without dispersing agent.

Bulk Density For 70% solids content $\bar{x}$ = 1790 kg/m³ and s = 25 kg/m³

Delivery Slurry is delivered in road tankers.

Storage In covered storage tanks with agitation.

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Telex: 16388 fxkalk • Aktieselskabet Faxe Kalkbrud reg. No. 173 (Danish limited company)

TYPICAL PROPERTIES FOR ALCOA HYDRAL™ SERIES ALUMINA TRIHYDRATES

Typical Chemical Analysis	Hydral™ 705	Hydral™ 710	Hydral™ PGA
Al_2O_3 (%)	64.1	64.1	64.7
SiO_2 (%)	.04	.04	.04
Fe_2O_3 (%)	.01	.01	.01
Na_2O (% Total)	.60	.45	.45
Na_2O (% Soluble)	.27-.50 max	.10-.25 max	.10-.25 max
Moisture (% at 110°C)	.6-1.0 max	.3-1.0 max	.5-1.0 max

Typical Physical Analysis	Hydral™ 705	Hydral™ 710	Hydral™ PGA
Bulk density, loose, g/cm^3	.08-.14	.13-.22	.35
Bulk density, packed g/cm^3	.09-.20	.26-.45	.70
Specific gravity	2.42	2.42	2.42
Surface area, m^2/g*	10-20	6-12	6-12
Mohs' hardness	2.5-3.5	2.5-3.5	2.5-3.5
Refractive Index	1.57	1.57	1.57
Color	white	white	white
TAPPI brightness	99+	99+	99+
Particle-size analysis (cumulative)			
% on 325 Mesh	.18	.15	.15
% less than 3 microns**	100	90	90
% less than 1 micron	90	50	50
% less than 0.5 micron	50	10	10

* Surface area measured by Brunauer-Emmett-Teller method of nitrogen adsorption

** As determined by sedigraph on a weight basis. PGA as fully deagglomerated. Actual agglomerated particles are larger.

235 EAST 42nd STREET
NEW YORK, N.Y. 10017

Pfizer Specialty Minerals

ALBAGLOS®

PFIZER MINERALS FOR HIGH PERFORMANCE PAPERS

ALBAGLOS®

This unique paper coating pigment from PFIZER, with its precisely controlled particle size distribution, provides excellent high shear rheology needed for high solids blade coating applications. ALBAGLOS®, rhombohedral precipitated calcium carbonate, provides good paper gloss with improved ink receptivity and faster ink set time without sacrificing gloss ink holdout.

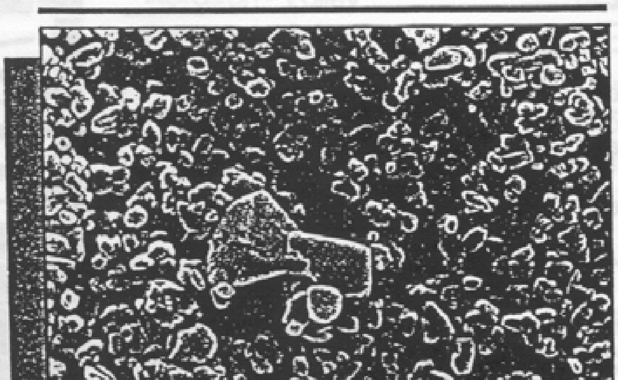
Typical Properties
PHYSICAL

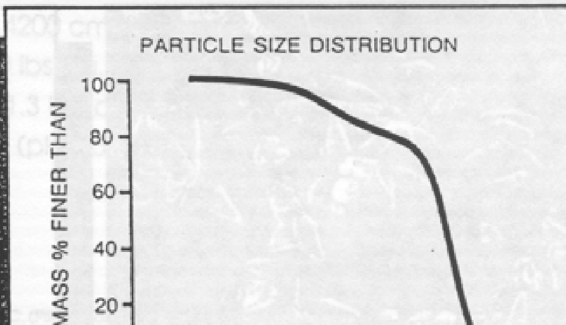
Mean Particle Size, μm. (Sedigraph 5100)	0.8
BET Surface Area (m^2/g)	7
Dry Brightness (Y) (Hunter D-25)	97
+ 325 Mesh Residue, %	0.02
% Solids, %	*

*Available Dry & 70% Solids Slurry

Typical Properties
CHEMICAL

$CaCO_3$, %	98
$MgCO_3$, %	1.0
Fe_2O_3, %	0.07
Acid Insolubles, %	0.10





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Pfizer Specialty Minerals

ALBACAR 5970®

PFIZER MINERALS FOR HIGH PERFORMANCE PAPERS

ALBACAR 5970®

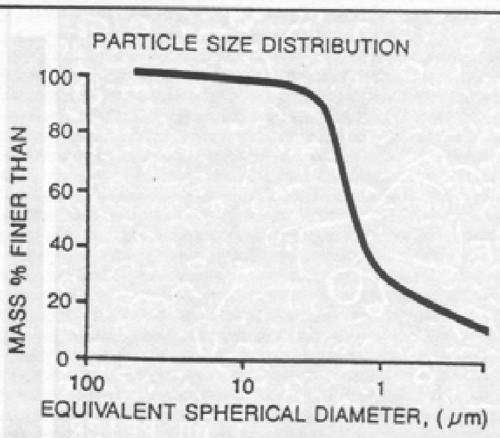
This unique paper filling mineral from PFIZER is suited for uncoated fine papers and coating base stock. ALBACAR 5970®, a scalenohedral precipitated calcium carbonate, improves opacity and brightness while tending to increase both the openness and the bulk of the filled paper.

Typical Properties
PHYSICAL

Mean Particle Size, μm. (Sedigraph 5100)	1.9
Dry Brightness (Y, Rd) (Hunter D-25)	97
% Solids	Dry
+ 325 Residue, %	0.05
Einlehner Abrasion, mg. (AT 1000 @ 174K rev.)	4.0

Typical Properties
CHEMICAL

$CaCO_3$, %	98
$MgCO_3$, %	1.0
Fe_2O_3, %	0.07
Acid Insolubles, %	0.10



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PRODUCT INFORMATION

PERGOPAK® M-2/HP

Introduction

PERGOPAK M-2 is an organic white pigment used as a filler in the production of paper and paperboard to provide opacity and brightness, to extend and replace TiO_2 and to improve printability. Pergopak M-2 conforms with the requirements of the FDA for use in paper and paperboard products used in food packaging under CFR 21, Part 181.30.

Characteristics

Fine, bulky white powder. Primary particles of 0.1 - 0.15 microns form agglomerates of 5.5 - 6.5 micron diameter.

Chemical Properties

Urea-formaldehyde condensate product with approx. 0.6% reactive methylol groups.

Nitrogen Content	33 ± 5% of the dry product
Volatile Constituent	30 ± 5%
Residue After Ignition	About 2%
Stability - Heat	Up to max. 200° C/390° F
Cold	Down to -28° C/-18°F
Free Formaldehyde	Less than 0.1%

Physical Properties

Brightness (TAPPI)	97 ± 1%
Surface Area	10 ± 2 m^2/g (BET method)
Refractive Index	1.58 (20°C/70°F)
pH (3% dispersion)	8 ± 0.5
Abrasion - Valley	1 - 3 mg
Scattering Coefficient	About 4200 cm^2/g (Kubelka and Munk)
Bulk Density	4.8 - 6.0 lbs/cu. ft. (80 - 100 kg/m^3)
Packaged Density	10.5 - 11.3 lbs/cu. ft. (170 - 180 kg/m^3)
Zeta Potential	Positive (pH 4.5 - 7.5)

Packing

12 kg (26.4 lbs) white repulpable bags

0289