Foth & Van Dyke

REPORT

Mining Permit Application for the Flambeau Project

Scope I.D.: 87K10

Volume II - Appendices

Flambeau Mining Company
Ladysmith, Wisconsin

Revised December 1989

EXHIBIT
11
Vol. 2 of 2

MINING PERMIT APPLICATION
FOR THE FLAMBEAU PROJECT

LIST OF APPENDICES

APPENDIX A

Property Deed and Legal Description

LAW OFFICES

DeWITT, PORTER,

HUGGETT, SCHUMACHER & MORGAN, S.C.

Two East Mifflin Street, Suite 600
Madison, Wisconsin 53703
Telephone: (608) 255-8891 Facsimile: (608) 252-9243

September 13, 1989

HAND DELIVERED

Mr. Jerry Sevick
Foth & Van Dyke
2737 South Ridge Road
P.O. Box 19012
Green Bay, WI 54307-9012

Re: Kennecott Mining Permit Application -- Supplemental Transmission of Deeds

Dear Jerry:

Under NR 182.09, a person submitting a mining permit application must include as an appendix to the application a copy of the property deeds relating to the site on which NR 182 facilities will be located. When Kennecott submitted its mining permit application to the DNR on April 1, 1989, it indicated that property deeds would be submitted under separate cover. That material is now enclosed.

When reviewing this material, two points should be noted. First, while the deed which Flambeau Mining Company received is merely a quit claim deed, it is insured by a title insurance policy issued to Flambeau Mining Corporation's parent company. This means that a title insurance company has reviewed the legal chain of title and is willing to insure that Kennecott Minerals Company had full legal title to the properties which it conveyed to Flambeau Mining Corporation.

Second, the deed encompasses considerably more land than merely the waste site area or even more than the project area. For reference purposes, the project area is defined in the mining permit application as follows:

> That part of Section Nine (9), Township Thirty-Four (34) North, Range Six (6) West, Rusk County, Wisconsin, lying east of the Flambeau River and south of Blackberry lane; and the area required for an approximate one-mile long railroad spur located in part of Section Ten (10), Township Thirty-Four (34) North, Range Six (6) West, Rusk County, Wisconsin, lying west of the main line of the Wisconsin Central Limited.

This area is shown in Figure No. 1-1 of the mining permit application.

Please let me know if either the Department of Transportation or Department of Natural Resources is interested in further documentation or if they have any questions with respect to this transaction.

Very truly yours,

Paul G. Kent

Paul G. Kent

PGK:bmf
Enclosures

222744

DEED
(Flambeau Project)

KENNECOTT MINERALS COMPANY, a Delaware corporation (hereinafter designated "Grantor"), hereby quitclaims to FLAMBEAU MINING INC., a Delaware corporation, whose address is 10 East Temple, P.O. Box 11248, Salt Lake, Utah 84147 (hereinafter designated "Grantee"), for the sum of Ten Dollars ($10.00) and other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged by Grantor, the following described real property, and including all patented mining claims and unpatented mining claims and interests therein and all riparian and littoral rights pertaining thereto (herein designated the "Subject Properties") situated in Grant Township, Rusk County, State of Wisconsin:

See Exhibit A attached hereto
and hereby incorporated herein.

For the same consideration, Grantor hereby transfers and conveys or agrees to cause to be transferred or conveyed to Grantee, without warranty, any and all additional right, title or interest in or to the Subject Properties which Grantor may now have or at any time hereafter acquire.

IN WITNESS WHEREOF, Grantor has caused its corporate name and seal to be hereunto affixed this/ 30th day of June, 1989.
23rd day of June, 1989, to be effective the

KENNECOTT MINERALS COMPANY

TRANSFER
$ 171,000.00
FEE

By: [signature]
G. J. Dunn
Title: Vice President

ATTEST:

By: P.S. Gibbs
P.S. Gibbs
Title: Assistant Secretary

REGISTER'S OFFICE } SS.
RUSK COUNTY

Received for Record the 30th day of June A D 1989 at 2:00 o'clock P M and recorded in Vol. 260 of Records on page 270-275

Mary Lu Riel
Mary Lu Riel
Register of Deeds

INDEXED

STATE OF Ohio)
)
Cuyahoga COUNTY)

On this, the 23rd day of June, 1989, before me, the undersigned officer, personally appeared G.J. Dunn P.S. Gibbs and ________, who acknowledged themselves to be the Vice President and Asst. Secretary, respectively, of KENNECOTT MINERALS COMPANY, a corporation, and that they, as such officers, being authorized so to do, executed the foregoing instruments on behalf of said corporation, for the purposes therein contained.

IN WITNESS WHEREOF, I have set hereunto my hand and official seal.

[NOTARIAL SEAL]

Name: Eileen Gawlik
Notary Public, ________ County
STATE OF ________
My Commission:

EILEEN GAWLIK
Notary Public, State of Ohio
Recorded in Cuyahoga County
My Comm. Expires 10-23-90

This instrument was drafted by and after recording should be returned to David S. Lott, Foley & Lardner, 777 East Wisconsin Avenue, Milwaukee, Wisconsin 53202.

EXHIBIT A

The real estate premises are described as follows:

The South one-half of the South one-half of the Northeast Quarter of the Northeast Quarter, the Northwest Quarter of the Northeast Quarter, except beginning at the Northeast (NE) corner of said Northwest Quarter of the Northeast Quarter, thence West along the South line of the existing road Four Hundred Ten (410') feet, thence South Two Hundred Twelve and 5/10 (212.5') feet, thence East Four Hundred Ten (410') feet, thence North Two Hundred Twelve and 5/10 (212.5') feet to the point of beginning, the Southeast Quarter of the Northeast Quarter, the Northeast Quarter of the Southeast Quarter, the Southeast Quarter of the Southeast Quarter, Government Lots Three (3), Four (4), Five (5), Six (6), Seven (7), and Eight (8), Section Nine (9), Township Thirty-four (34) North, Range Six (6) West.

That part of the Northwest Quarter of the Northeast Quarter lying East of the Railroad, Section Ten (10), Township Thirty-four (34) North, Range Six (6) West, except that part of Lot One (1) of Certified Survey Map, Page 284; That part of Government Lot Seven (7), Section Three (3), Township Thirty-four (34), Range Six (6) West lying West of Railroad, that Part of the Northwest Quarter of the Northeast Quarter of Section Ten (10), Township Thirty-four (34) North, Range Six (6) West lying West of Railroad; that Part of the Southwest Quarter of the Northeast Quarter lying East of Railroad, that Part of the Southwest Quarter of the Northeast Quarter lying West of Railroad, the Southeast Quarter of the Northeast Quarter, the NOrtheast Quarter of the Northwest Quarter, that Part of the Northwest Quarter of the Northwest Quarter lying East of State Highway 27, excepting parcels described as follows:

A parcel in the Northwest Quarter of the Northwest Quarter commencing at the Northeast corner, thence 200 feet West, thence 66 feet South, thence 200 feet East, thence 66 feet North to the point of beginning; and

Commencing at the intersection of the South right-of-way line of a Town Road with the East right-of-way line of State Highway 27; thence Southerly along said East right-of-way line 175 feet, thence Easterly at right angle, 150 feet, thence Northerly at right angles and parallel to said East right-of-way line, 215 feet to the South line of Town Road, thence Westerly along town road 156 feet, to the point of beginning; and

Commencing at the intersection of the South right-of-way line of a Town Road with the East right-of-way line of State Highway 27, thence Southerly along said East right-of-way line, 175 feet, to the point of beginning of the land to be herein described; thence Southerly along the East line of Highway 208.7 feet, thence Easterly at right angles, 208.7 feet, thence Northerly at right angles and parallel to said East right-of-way line, 208.7 feet; thence Westerly at right angles, 208.7 feet to the point of beginning.

The Southwest Quarter of the Northwest Quarter, the Southeast Quarter of the Northwest Quarter, the Northeast Quarter of the Southwest Quarter, the Northwest Quarter of the Southwest Quarter, the Southwest Quarter of the Southwest Quarter, the Southeast Quarter of the Southwest Quarter, the Northeast Quarter of the Southeast Quarter, the Northwest Quarter of the Southeast Quarter lying East of Railroad, the Northwest Quarter of the Southeast Quarter lying West of Railroad, the Southwest Quarter of the Southeast Quarter lying East of Railroad, the Southwest Quarter of the Southeast Quarter lying West of Railroad, the Southeast Quarter of the Southeast Quarter of Section Ten (10), Township Thirty-four (34) North, Range Six (6) West.

Government Lots One (1), Two (2) except a parcel of land lying within Government Lot Two (2), Section Sixteen (16), Township Thirty-four (34) North, Range Six (6) West described as follows: Commencing at the Northwest corner of said Section Sixteen (16), said corner being the center line of North and South Town Road and intersection of East and West fence, thence North 89°0'E along the North line of Section Sixteen (16) a distance of 594.4 feet; thence South 37°30'E a distance of 2860.9 feet; thence South 56°15'E a distance of 341.1 feet to the point of beginning; thence South 33°45'W a distance of 50.0 feet, thence South 56°15'E a distance of 197.0 feet to an intersection with the Northwesterly edge of the Flambeau River; thence North 37°11'E a distance of 50.09 feet; thence North 27°17'E a distance of 150.96 feet, thence North 56°15'W a distance of 183.0 feet; thence South 33°45'W a distance of 150.0 feet to the point of beginning, Three (3), Four (4), Five (5), Six (6) except a parcel of land lying within Government Lot Six (6), Section Sixteen (16), Township Thirty-four (34) North, Range Six (6) West, said parcel being more particularly described as follows: Commencing at the southeast corner of said Section Sixteen (16), said corner being the intersection of the corner line of State Highway 27 and the center line of County Road T, thence north no (0) degrees, three (03) minutes west along the center line of State Highway 27 a distance of eight hundred forty and one-tenths (840.0) feet; thence north fifty-three (53) degrees fifty-one (51) minutes west a distance of eighteen hundred fifty-four and two-tenths (1854.2) feet; thence north fifty-six (56) degrees, fifteen (15) minutes west a distance of six hundred forty-seven and no-tenths (647.0) feet to the point of beginning; thence south thrity-three (33) degrees forty-five (45) minutes west a distance of fifty and no-tenths (50.0) feet; thence north fifty-six (56) degrees, fifteen (15) minutes west a distance of one hundred ninety eight and two-tenths (198.2) feet to an intersection with the southeasterly edge of the Flambeau River; thence north thirty-one (31) degrees, forty-one (41) minutes east a distance of fifty and three one-hundredths (50.03) feet; thence north thirty (30) degrees forty (40) minutes east a distance of one hundred fifty and twenty-two one-hundredths (150.22) feet, thence south fifty-six (56) degrees, fifteen (15) minutes east a distance of two hundred eight and 08/100 (208.08) feet, thence south thirty-three (33) degrees, forty-five (45) minutes west a distance of one hundred fifty and no-tenths (150.0) feet to the point of beginning, Seven (7), and Eight (8); the Northwest Quarter of the Northwest Quarter, the Northeast Quarter of the Southeast Quarter, the Southwest Quarter of the Southeast Quarter, the Southeast Quarter of the Southeast Quarter of Section Sixteen (16), Township Thirty-four (34) North, Range Six (6) West.

Government Lots Three (3), Four (4), Five (5), Six (6), and Seven (7), the Northeast Quarter of the Northeast Quarter, the Northwest Quarter of the Northeast Quarter, of Section Seventeen (17), Township Thirty-four (34) North, Range Six (6) West.

The Northeast Quarter of the Northeast Quarter, the Southwest Quarter of the Northeast Quarter, the Southeast Quarter of the Northeast Quarter, the East one-half of the East one-half of the Northwest Quarter, the Northeast Quarter of the Southeast Quarter of Section Twenty (20), Township Thirty-four (34) North, Range Six (6) West.

the Southwest Quarter of the Southeast Quarter, The Northeast Quarter of the Northeast Quarter, the Northwest Quarter of the Northeast Quarter, the Southwest Quarter of the Northeast Quarter, the Southeast Quarter of the Northeast Quarter, the Northeast Quarter of the Northwest Quarter, the Northwest Quarte of the Northwest Quarter, the Southwest Quarter of the Northwest Quarter, the Southeast Quarter of the Northwest Quarter, the Northeast Quarter of the Southwest Quarter, the Northwest Quarter of the Southwest Quarter, the Northeast Quarter of the Southeast Quarter, the Northwest Quarter of the Southeast Quarter, the Southwest Quarter of the Southeast Quarter of Section Twenty-one (21), Township Thirty-four (34) North, Range Six (6) West.

The Southwest Quarter of the Northwest Quarter, and the Northwest Quarter of the Southwest Quarter of Section Twenty-two (22), Township Thirty-four (34) North, Range Six (6) West.

Located in the City of Ladysmith, and Township of Grant, Rusk County, State of Wisconsin.

APPENDIX B

Local Agreement

LOCAL AGREEMENT

BETWEEN RUSK COUNTY, THE TOWN OF GRANT,

THE CITY OF LADYSMITH

AND

KENNECOTT EXPLORATIONS (AUSTRALIA) LTD.

FOR

DEVELOPMENT OF THE

KENNECOTT FLAMBEAU MINE

LOCAL AGREEMENT

INDEX

EXHIBITS

AGREEMENT BETWEEN RUSK COUNTY, THE TOWN OF GRANT,

THE CITY OF LADYSMITH

AND

KENNECOTT EXPLORATIONS (AUSTRALIA) LTD.

WHEREAS, the County of Rusk, the Town of Grant and the City of Ladysmith have formed a Local Impact Committee for, among other things, the purpose of representing local governments to protect local interests while developing workable rules under which the mining project proposed by Kennecott Explorations (Australia) Ltd. (Kennecott) can proceed in Rusk County;

WHEREAS, portions of Sections 9, 10, 16, 17, 20 and 21, T-34N, R6W Rusk County in the Town of Grant have been identified as a site with a mineral deposit;

WHEREAS, Kennecott owns the mineral deposit and is interested in developing such deposit into an Open Pit copper mine;

WHEREAS, Rusk County, the Town of Grant and the City of Ladysmith have exercised the authority granted in section 144.838 and 144.839, Wisconsin Statutes, by establishing a Local Impact Committee to negotiate with Kennecott relative to the proposed copper Mine;

WHEREAS, Rusk County, the Town of Grant and the City of Ladysmith have exercised the authority granted in section 144.838 of the Wisconsin Statutes by appointing two members each to the Local Impact Committee; and

WHEREAS, the Town of Grant, Rusk County, City of Ladysmith, and Kennecott are desirous of completing these negotiations in a timely and equitable fashion.

NOW, THEREFORE IT IS AGREED, by and between the Town of Grant, Rusk County, the City of Ladysmith and Kennecott that the following definitions shall be used to interpret the meaning of items contained within this Agreement.

"Active Mine Area" shall mean the operations area of the Operator's land including the Open Pit, itself, as well as the water treatment facility, crushing and loadout facility, runoff catchment, administration center, stockpiled material for backfill, overburden, topsoil and settling ponds, as identified with reference to Exhibit A, but excluding the railroad spur and utility lines.

"Active Mining" shall mean and include all phases of construction and operation of the Mine.

"Baseline Monitoring Program" shall mean that period of time and that phase of the proposed mining operation during which baseline data, as defined in Sec. NR132.03(2) is being collected and analyzed.

"DNR" shall mean the Wisconsin Department of Natural Resources.

"Downgradient Wells" shall mean all wells located west and northwest of the Open Pit, between the Pit and the Flambeau River and as far north as Blackberry Lane.

"Earthen construction" shall mean the berm which the Operator shall construct in the Active Mine Area to contain wastes and wastewater treatment ponds.

"Emergency" shall mean, for the purposes of section 10, only those times when due to strikes, acts of God, accidents or force majeure, the railway line serving the Mine cannot transport Ore away from the Mine.

"EPA" shall mean the United States Environmental Protection Agency.

"Gossan" shall mean gold bearing ore.

"Hazardous Waste" shall have the meaning set forth at Sec. 144.43(2), Wisconsin Statutes.

"Leachate" shall have the meaning at Sec. NR182.04(26).

"Local Impact Committee" shall mean the committee designated by the Town of Grant, Rusk County and the City of Ladysmith to negotiate, subject to each of the parent municipality's satisfaction, this Agreement, and any successor committees hereto, whether designated pursuant to Secs. 144.438 or 66.30, Wisconsin Statutes, or under other statutory authority.

"Metallic Mineral" shall have the meaning at Sec. NR132.03(9).

"Mine" shall mean all of the operations associated with the Open Pit mine sought to be developed under this Agreement by Kennecott.

"Mine Operation" shall mean that phase of the mining project which shall begin after the necessary DNR permits have been granted and after construction has been concluded, to consist of the process, over several years of time, of the extraction and of the shipping of Ore. It shall end with the conclusion of the Ore extraction process, shipping of the Ore and the commencement of the closure.

"Mineral Deposits" shall mean the body of Ore from which Kennecott proposes to extract copper and gold.

"Mining" shall have the meaning at Sec. NR132.03(11).

"Mining Operation" shall mean and include all phases of construction, operation and closure of the Mine.

"Open Pit" shall mean that area on the surface of Operator's land which the Operator intends to excavate and from which Ore will be extracted.

"Operator" shall mean and include the following: The person applying for (Applicant) all necessary local, state and/or federal permits with which to operate the Mine subject to this Agreement, the Owner of the land on which the Mining Operation will take place and the Owner of the Ore extracted therefrom.

"Operator's Rentals" shall mean those houses, business buildings, other structures, and real estate owned by the Operator, but rented or leased by it to third parties for their use and occupation.

"Ore" shall have that meaning set forth at Sec. NR132.03(17).

"Owner," "Applicant" or "Operator" shall mean Kennecott.

"Participating Local Governments" shall mean the Town of Grant, the County of Rusk and the City of Ladysmith, all of which are located in the State of Wisconsin.

"Pollution" shall have the meaning set forth at Sec. 144.01(10), Wisconsin Statutes.

"Secured Area" shall mean all of the Operator's land situated inside of the Security Fence.

"Security Fences" shall mean a fence capable of preventing human beings from intruding into the Active Mine Area, to consist generally of a six (6) foot high chain link fence with three strands of wire on the top.

"Temporary Closure" shall mean an unanticipated cessation of Active Mining operations not to exceed six (6) months whether caused by a strike or strikes, force majeure or other reasons.

"Test Materials" shall mean the equipment, supplies, chemicals and/or other items necessary to take and test water samples.

"Ton" shall mean 2000 American pounds.

"Town Board" shall mean the Board of the Town of Grant, Rusk County, Wisconsin, and where the circumstances dictate, it shall refer to the City Council of the City of Ladysmith.

"Town Officials" means any person legally holding the elective offices of Town Chairman, Town Supervisor, Town Clerk, Town Treasurer and Town Assessor. For purposes of this Agreement, said term shall also include officials of the City of Ladysmith occupying the same or similar positions, whether elected or appointed, under circumstances wherein such interpretation should be given to the term.

"Well Cluster" shall mean 2 or more wells installed within 10 feet of each other at the ground surface and constructed to varying depths.

IT IS FURTHER AGREED THAT:

1. DNR PERMITS/PERFORMANCE BOND

   The Owner or Operator of the Mine will secure all necessary licenses and permits from the DNR. The Operator will furnish a copy of the performance bond or other approved security set by the DNR to the Local Impact Committee

2. MINING PERMIT

   Operation of the Mine shall comply with all DNR regulations in NR 132 applicable to the Mine and associated facilities except as to exemptions from such regulations as may be granted to the Operator by the DNR in accordance with NR 132.19, Wis.Adm. Code, in which cases the Operator shall comply with such alternative regulations, if any, as are imposed by the DNR. The Local Impact Committee will be provided copies of all pertinent documents which Kennecott provides to the DNR pertaining to any request for an exemption. A copy of the mining permit and plan of operation, and any modifications thereto, if any, submitted to and approved by the DNR as a requirement for licensing will be made a part of this Agreement.

The Operator shall take preventative measures to minimize surface water runoff or erosion and to accomplish that purpose will finish grading and will seed completed areas of the Mine in accordance with the closing plan made a part of this Agreement.

3. PROJECT OVERVIEW

Project Scope and Limitations:

a. The Mine, inclusive of appurtenant structures and facilities, but excluding the railroad spur, access roads, and utility feed lines, shall be situated on land whose legal description is as set forth in Exhibit B. It shall consist of an Open Pit, from which the Operator intends to extract topsoil, overburden waste rock and Ore, the purpose of which Open Pit shall be to remove Ore containing copper, silver and gold. The topsoil, waste rock and overburden shall be stored for use in restoration of the Open Pit during the Mine's closure phase.

b. Dimensions of the Open Pit and Active Mine Area: the Open Pit shall be no greater than 40 acres, more or less, in size and shall be excavated to a depth of no more than 225 feet, more or less, below the grade existing on the site as of January 1, 1988.

c. Limitations: The Mine herein described shall be subject to the following limitations:

(1) There shall be no conversion from an Open Pit to deep shaft mineral mining.

(2) There shall be no smelting, concentrating or refining of Ore on the Operator's land or in Rusk County.

(3) There shall be no material expansion of the Mine without first reopening this Agreement and any zoning land use permits granted in accord herewith. "Material expansion" shall mean any substantial increase or variation in the size, scope or intent of the Operator as to the instant Mining Operation which varies with the description of the project as herein contained and as correspondingly established in the DNR permit process. "Substantial increase or variation in the size, scope or intent of the Operator" shall be further defined as any such increase or variation in the size, scope or intent as to the instant Mining Operation which shall exceed in excess of ten (10) percent (%), the parameters for the project as set forth in paragraph 3 b. of this Agreement. It shall not include minor variations on either the size in acres or depth of the Open Pit as evidenced by the approximate dimensional criteria set forth at b. above, nor shall it include variations in annual activity during the Mine Operation phase of the project due to production fluctuations. Material expansion shall not pertain to amounts of Ore shipped in any year nor over the life of the project.

(4) The Active Mine Area shall, at all times during the construction, operations and closure phases of the project, be enclosed by the Security Fence, entry through which shall be via secured gates.

(5) The Operator shall install, maintain and utilize surface water containment systems and a water treatment plant to protect the groundwater and surface

water of Rusk County in accordance with DNR specifications.

(6) The topsoil, waste rock and overburden removed from the Open Pit shall be stock piled for use in site restoration during the Mine closure phase.

(7) Except as otherwise allowed in this Agreement, all transportation of Ore away from the site shall be via railroad.

(8) Such other and further limitations as are expressed in this Agreement or by the DNR shall also apply to the proposed Mine.

(9) The restrictions herein enumerated as to hours and days of operation.

(10) 300,000 Tons of ore per year shall be the approximate projected amount of ore to be shipped from the Mine each year.

d. The Mine and operations related thereto shall consist of three (3) phases, those being: (1) Construction; (2) Mine Operation; and (3) Closure.

4. SETBACKS

Structures in the Active Mine area shall be kept at least 250 feet from adjacent property owned by others except for the distance from the Flambeau River and other streams within the Active Mining Area and from roads and shall at no time exceed 225 acres. The total Open Pit area shall not exceed 40 acres. The 250 foot buffer to adjacent property shall be maintained in existing natural vegetation to act as an aesthetic, visual barrier. The Open Pit contemplated herein shall be excavated no deeper than approximately 225 feet below the grades existing at the Active Mine Area on January 1, 1988.

5. GATES AND VISITORS OBSERVATION AREA

The Operator shall construct and maintain gates of sufficient strength to control access to the Mine. The gates shall be closed and kept locked by the Operator except during the hours of operation.

The Operator will provide an area to allow visitors to park and observe the Mining Operation.

6. SECURITY FENCING

Security Fences shall be used to surround the Active Mine Area to prevent unauthorized entry. These Security Fences shall be in place prior to operation, and maintained and used during the life of the Mine. Commencing with construction start up and continuing through closure of the Mine, the Operator shall repair the Security Fences as needed.

7. CONSTRUCTION SUPERVISION/INSPECTION

All earthen construction of the Mine, its storage areas and wastewater treatment ponds shall be under direct supervision/-inspection of a registered professional engineer.

8. HOURS OF OPERATION

Blasting, crushing and rail shipping operations shall be conducted during daylight hours, Monday through Saturday only.

9. ACCEPTABLE WASTE TYPES

The only non-hazardous wastes to be stored at the Mine are those wastes as defined by DNR and generated by the operations. The Operator shall not accept, receive, store or dispose of any Metallic Mineral from any other mine without Local Impact Committee approval, except those materials necessary for operation of the Mine and facilities. No Hazardous Waste, as currently defined by the DNR according to NR 181.12, regardless of quantity, shall be accepted, received, stored, disposed of or transported to the Mine and Operator agrees that it shall not, at any time, apply to the DNR for a Hazardous Waste permit to store, or to dispose of any material currently defined as Hazardous Waste, at the Mine, or at any location in Rusk County.

This section does not preclude on-site storage of fuels, lab chemicals and blasting materials, provided they are contained in secured areas. This section also shall not apply to any precipitate resulting from water treatment activities.

10. OFF-SITE ACCESS ROADS

During the life of the Mine, Operator, its employees and agents transporting Ore to and from the Mine by truck shall be limited to access, to and from the Mine, from State Highway 27 via Blackberry Lane, a town road as of the time of execution of this Agreement, unless a new access road is constructed entirely at the expense of the Operator. Use of Jensen Road, Meadowbrook Road and Doughty Road, lying to the east of State Highway 27, for Ore hauling purposes, shall be limited to those emergency situations when the rail spur serving the Mine is impassible or inoperable and only for the purpose of gaining access to and from the main railway line to which said spur line is connected. The Operator shall construct, maintain and repair, to Town Road Standards as established by the Wisconsin Department of Transportation, and as amended or revised from time to time, those portions of the designated access road which are under Town jurisdiction and which are used by trucks for transporting Ore to or from the Mine to the extent that they remain as public roads. The Operator may contract with the Town, any other municipality or private firms for said maintenance and repair, including such graveling, grading and snow plowing as is necessary. Said maintenance and repair responsibilities shall continue throughout the period of active Mining. Notwithstanding the language above, the primary means of transporting Ore to and from the Mine shall be by rail. The use of trucks for transporting Ore to and from the site shall be limited to emergency situations, or for special shipments of Ore containing significant amounts of gold bearing Gossan if required for special shipments. The use of trucks to transport to and from the Mine during the closure phase shall be negotiated separately prior to the end of the active Mining phase.

Emergency situations, as that term is used herein, shall not include the closure of the rail line or lines over which the Ore is intended to be transported for periods of time in excess of one month whether due to employee strikes, weather or other conditions, either within or outside of the control of the said rail line or rail lines, nor shall such conditions exist if the railroad, currently the Wisconsin Central, Ltd., or its successor in interest, to which the Mine spur line would be connected, abandons its line to which the spur is connected. Under any of the circumstances herein described, the Operator agrees to confer with the Local Impact Committee as to alternative means of transportation and their environmental, social and governmental effects and means of minimizing the same.

The restriction in sections 10 and 11 to the effect that conditions are imposed upon the use of trucks for the hauling of Ore to and from the Mine shall not apply with respect to sample shipments for testing purposes or other small shipments which are capable of being transported in trucks whose gross loaded weight does not exceed 10,000 pounds.

11. TRUCKING RESTRICTIONS

In the event that trucks are used as referred to under section 10, such use shall be subject to the following restrictions:

(a) No trucks shall transport Ore on Town roads during any other than daylight hours.

(b) This section and section 10 shall also apply to any Town roads which are ultimately annexed by the City of Ladysmith.

(c) The Operator shall clean all truck tires before such trucks exit on to any hard surfaced public road.

(d) The Town Board may set speed restrictions on any Town Roads or Town roads which are ultimately annexed by the City used for transporting Ore, pursuant to s. 349.11, Wisconsin Statutes.

(e) Any trucks transporting Ore on public roads shall be maintained to minimize leaks and shall be covered.

(f) All internal haul roads at the Mine site shall be restricted to prevent any public access.

It is agreed that the primary means of transporting Ore from the Mine to off-site facilities for smelting, processing and refining shall be via railway. To this effect, the Operator agrees that it shall, before Mining and extraction begin, take the necessary steps to have constructed and place into operation a spur line connecting the Mine with the main line of what is presently the Wisconsin Central, Ltd., east of the Mine.

12. HIRING OF EMPLOYEES

Over the life of the operation, Kennecott shall, in accordance with applicable law, assure that after the start of Ore shipments, an average of 75% of the mine workers shall be persons who have resided in or within 10 miles of Rusk County for a period of at least one year prior to hiring, whether hired directly by Kennecott or by any contractor/subcontractor hired by Kennecott. Contracts awarded by Kennecott shall contain local hiring goals for this purpose.

13. GROUNDWATER MONITORING WELLS

Not less than 6 groundwater monitoring Well Clusters shall be constructed within the Active Mine Area as indicated in Exhibit C. These wells are to be tested on at least a quarterly basis during the Baseline Monitoring Program, construction, and operation. In the event that a background of ground water contamination or content of minerals or other substances is ascertained which exceeds any applicable state or federal health standards, which discovery is made during base line testing, the well owner or owners shall be notified. Monitoring after closure shall be in accordance with the DNR approved reclamation plan. If testing of Downgradient Wells indicates that water quality does not meet primary and secondary drinking standards and if water quality indicates a significant deterioration from the background testing required herein, written notice shall be immediately sent by the Operator to all existing Downgradient Well owners within the area indicated on Exhibit D, attached hereto, informing them of the results and requesting permission to test their wells within 48 hours.

14. TESTING/GUARANTEE OF PRIVATE OFF-SITE WELLS

In addition to monitoring wells on the Mine site and surrounding the Mine site in accordance with this Agreement and DNR regulations, the Operator will also pay for and be responsible for the following:

a. The Operator shall test all existing active wells with respect to both quality and quantity, to establish background data, including those serving the Operator's rentals, within the area indicated on the map attached hereto as Exhibit D, at least twice prior to construction of the Mine and provided the owners not party to this Agreement give permission.

b. If, after commencement of mining, any well tests within the area indicated on Exhibit D indicate contamination or

Pollution, or if recommendations are issued by DNR not to use such well or wells for human consumption, Operator shall immediately following such discovery and also at least once a year thereafter test all active wells within the area indicated on Exhibit D and continue such testing for 20 years thereafter, unless it is proven that the contamination or Pollution is not caused by the Mine, or such condition is corrected, in which case such further testing shall no longer be required, or such requirement is waived, in writing, by the Local Impact Committee provided for herein. Such waiver shall not be unreasonably withheld.

c. Appropriate records shall be maintained and kept during this time period. The results of all tests on and off site shall be filed with the Town Clerk and Local Impact Committee.

d. The parameters to be tested are: field ph, field conductivity, acidity, chemical oxygen demand, iron, hardness, alkalinity and chlorides. Tests are to be conducted in accord with standard EPA or DNR approved methods. If the tests indicate a significant adverse change in any of the parameters from the baseline data the Operator will perform additional tests for other elements such as sulfates, arsenic, cadmium, chromium, lead, mercury and zinc to determine the cause of the change.

Test materials shall be furnished by the Operator, who shall be responsible for taking samples.

If during the period commencing with the start of the Mining Operation and ending 20 years after the Mine ceases to operate any well within the area indicated on the map attached as Exhibit D has evidence of contamination, Pollution or has written recommendations by the DNR not to be used for human consumption, it shall be presumed that failure of the well has occurred and that failure was caused by the Mine, unless Operator, at it own expense, proves otherwise. Owners who do not grant the Operator permission to test their wells as indicated in a., above, shall not be eligible for relief granted hereunder.

Where well failure is presumed, as indicated above, the Operator shall, upon notice by the Town Board, provide an alternate and adequate source of water for domestic consumption, and for livestock consumption where applicable. In addition, the Operator shall assume all municipal responsibility under Sec. 144.855 (4) Wis. Stats., for any damage to those owners' water supplies, until such time as responsibility is proven otherwise. As used in this sub-section, "municipal" shall include the Town of Grant as well as the City of Ladysmith.

If the Operator undertakes the municipal responsibilities under Sec. 144.855 (4) Wis. Stats., and provides an alternate source of water and it is later determined by the DNR or a court that the Mine is not the cause of damage to a private water supply, the Operator may elect to be reimbursed for all the costs of supplying water, during a period not exceeding one year, under this Agreement by the third party to whom such water was supplied. The Operator shall have no responsibility to furnish compensation or an alternative supply of water under these provisions unless the party to whom compensation is provided or to whom the water is supplied signs an agreement with the Operator acknowledging the Operator's right to reimbursement.

15. COMPENSATION FROM LOSS IN PROPERTY VALUE DUE TO PROXIMITY OF MINE

During the period commencing with the start of the Mining Operation and ending 20 years after the Mining Operation ceases, any private land owner or tenant, or his or her successor in interest utilizing a well or wells located within the area set forth in Exhibit E, who feels they have suffered a tangible, monetary loss as a direct result of their proximity to the Mine, may appear at any regularly scheduled meetings of the Local Impact Committee to present any claims of loss in property value due to their proximity to the Mine and which loss exceeds any other prevailing losses to similar property values in the County. The Local Impact Committee will hear all testimony relative to the compensation claim. An investigation may also be made of the facts in the claim independently by the Local Impact Committee.

Prior to construction of the Mine, and with the cooperation of landowners within the above-mentioned area, the Operator, at his own cost, shall have all properties in the subject area and three comparable properties outside the subject area, but in Rusk County, appraised by an independent appraiser to establish base information. Any property owner or his or her successor in interest refusing to cooperate by allowing their property to be appraised shall not be eligible to seek relief under this section at a later date. If the Local Impact Committee does not agree with the appraisals, the Local Impact Committee shall obtain an independent appraisal. The cost of the appraisal shall be paid for in equal shares by the Participating Governments and reimbursed from the payment required in Section 21 herein. If two appraisals are not within 10% of one another, the Operator or the Local Impact Committee can request a third appraisal be made by a mutually acceptable appraiser. The average of the third appraisal and the closest appraisal will be used as the basis and the party whose appraisal is not used will pay for the third appraisal.

If any such claim cannot be settled through a meeting between the claimant, the Operator and the Local Impact Committee, claimants must supply a new appraisal from a licensed appraiser substantiating, in writing, the reasons for such loss in property values. The Operator, at its expense, shall also have a new appraisal prepared by a licensed appraiser again substantiating, in writing, reasons for any loss or in dispute of any loss in value of the subject property. The Local Impact Committee shall then have a review appraisal made of these two appraisals to determine whether there has been any decrease in value of the subject property solely due to its proximity to the Mine and to determine just compensation for any such loss in value substantiated by the Reviewer. The Local Impact Committee shall hire the review appraiser. These appraisals and reviews shall be conducted in accordance with DNR appraisal and review appraisal guidelines in effect at the time such reviews or appraisals are done or some other appropriate guidelines as agreed to by the parties.

If, based upon the review appraisal, the Local Impact Committee determines that the decrease in the value of the subject property was solely due to the proximity of the subject property to the Mine and the claim is justified, the Local Impact Committee shall determine that the amount of compensation representing the difference between the property without proximity and with proximity to the Mine shall be paid to the claimant. If a compensation award is made to the claimant, the Operator shall reimburse the claimant for appraisal costs in the manner indicated below. If no compensation is awarded, the claimant shall not be reimbursed for appraisal costs and shall reimburse the Operator for the Operator's appraisal costs. The Local Impact Committee shall have the power to assess Local Impact Committee costs and fees for conducting any investigation, in addition to compensation awarded.

The affected property owners shall have the right to elect to receive monetary damages if the property is sold in an arms length transaction, for the subject property's reduced market value due to the proximity to the Mine substantiated by the respective appraisals, unless the Operator, at its option, purchases the affected property from the claimant at its equalized valuation in the year preceding any determination of Loss. The equalized valuation for such purposes shall be calculated by the Town Assessor in the usual manner and shall not reflect any loss in value due to proximity to the Mine.

16. LOCAL MINING IMPACT COMMITTEE

Within ten days after the date of this Agreement, the County, Town and City shall establish a successor Rusk County Mining Impact Committee (Committee or Local Impact Committee) consisting of the chief elected official of the Town, County and City or their designee(s) who possess no conflict of interest relative to the Mine. For purposes of this Agreement,"conflict of interest" shall be defined as meaning that no member shall own real estate within one mile of the Mine, nor shall he or she be married to or related by blood to any person with a fee simple interest in real estate situated within one mile of the Mine or employed at the Mine. Any two members shall establish a quorum. Said Committee may hold such public meetings noticed pursuant to the Open Meeting Law as it deems to be appropriate. One or more of said meetings each year shall include a public forum to discuss concerns or problems with the operation of the Mine. This reference to public meetings shall not be construed as prohibiting the Committee from transacting business in closed session, where deemed appropriate and necessary by it, in accord with Sec. 19.85, Wis. Stats.

To assist the Local Impact Committee in its monitoring efforts and in order for the Local Impact Committee to maintain familiarity with the ongoing status of the mining operation, the following information will be provided by the Operator on an annual basis, if generated no more than one (1) time per year, or on a semi-annual basis, if generated more frequently than on an annual basis:

a. Verifiable information as to the amounts and types of Ore removed on an annual basis.

b. Copies of reports between the Operator and the DNR.

c. Copies of complaints that are received by the Operator from citizens, neighbors, local law enforcement officers, and the DNR.

d. Notice of any significant change in operational plans for the proposed site.

e. Copies of insurance certificates pertaining to the proposed site.

f. Such information as is necessary to update the Participating Local Governments officials as to any substantial changes in organizational structure of the Operator and the impact of such organizational changes on the Mining Operation.

The Local Impact Committee, at its discretion, shall also review, discuss, and inspect the site during reasonable time and with reasonable notice, hold public meetings and report findings to the Participating Local Governments on the following:

a. Any complaints or complaints received by the Operator or Committee from citizens relative to the Mine and this Agreement.

b. Specific compliance by the Mine Operator with this Agreement and DNR regulations.

c. Potential dangers, imminent hazards or public nuisances and recommended actions to mitigate them.

d. All other items that are pertinent to the Mine including transportation to and from, construction, operation, maintenance, closure and long-term care of the site.

Copies of the official minutes of all such meetings shall be provided to the Operator within 10 days of meetings. This requirement shall not apply to the minutes of closed sessions, if any are held by the Committee, which shall be subject to release to the Operator in accord with Sec. 19.35 (1) (a), Wis. Stats., or when the need to maintain confidentiality no longer exists.

The expenses of the Local Impact Committee shall be paid by the Operator and per diem for each member shall be $20.00 per meeting, plus verifiable travel expenses. Such reimbursement of Local Impact Committee costs by the Operator shall not exceed a $750.00 cap, annually. The per diem fee and reimbursement cap shall be increased annually by four percent (4%) commencing the year after the Mine begins operations, for not more than 20 years after the Mine ceases operations.

The Operator agrees to on-site inspection of the Mine by the Local Impact Committee and/or the Grant Town Board upon reasonable notice and a representative of the Operator will accompany the inspector at all times.

17. LEACHATE STORAGE AND TREATMENT

During the life of the Active Mining operation and during any period of Temporary Closure, the Operator shall continue to collect, pump to its wastewater treatment facility, and treat all waters which come into contact with sulfide mineralization which is of such characteristics so as to warrant treatment pursuant to NR 132. The Operator shall not dispose of, store or treat outside the Mine site any Leachate that has been removed from the Mine except Leachate treated pursuant to a WPDES/NPDES permit, nor shall the Operator accept, receive, store or treat at this Mine site any Leachate from any other mine. Any drippings resulting from spraying Ore in rail cars to control dust shall not be classified as Leachate for purposes of this section. Ice, snow and water from precipitation which may accumulate in rail cars during the course of loading and/or shipping, shall also be exempt from classification as Leachate.

To facilitate collection and treatment of water which comes in contact with potential sulfide mineralization and can produce a leachate that does not meet State standards the Operator agrees that it shall store the waste rock, which is removed from the Open Pit and contains sufficient sulfides that when leached by rain water will produce a discharge which is greater than the State standards will allow, on sites within the active mine areas specifically prepared for such storage. Said sites shall be lined to prevent seepage into the water table from occurring and shall be equipped with water collection pipes and equipment into which the water shall be channeled for treatment through the waste water treatment facility.

18. EMERGENCY EQUIPMENT AND PLAN

The Operator shall maintain a reliable communication system at the Mine using radio and/or telephone, so that contact can be made with the providers of emergency services, should the need arise.

The Operator will provide an emergency/security lighting system at the Active Mine Area during the hours of darkness.

The Operator shall prepare and issue to the Local Impact Committee an Emergency Preparedness Plan prior to filing a mining permit application with the DNR. Comments from the Local Impact Committee will be reviewed and incorporated if mutually agreed upon.

The plan submitted shall identify hazards peculiar to this Mine, such as steep slopes, blasting and heavy equipment use and, additionally, shall provide information to emergency responders as to chemicals or other materials stored on premises which may present particular fire fighting hazards. In addition, the plan shall detail how emergencies associated with hazards associated with the Mine shall be dealt with by the Operator and shall include special instructions to any local governments responsible for administration of emergency responses. With respect to the emergency plan to be developed by the Operator, reasonable recommendations of the Participating Local Governments shall be incorporated into the plan.

19. SUCCESSION OF AGREEMENT

This Agreement shall be binding on all parties, their heirs, successors or assigns until its termination by mutual consent of the parties or at the expiration of the mining permit granted to the Operator by the DNR pursuant to NR 132, Wis. Adm. Code, whichever first occurs. This Agreement shall run with the land and a short form of this Agreement giving notice of this Agreement shall be recorded in the appropriate tract in the office of the Register of Deeds. All sections of this Agreement relating to closure, long-term care, insurance, sale or lease of the Mine or its operation, escrow funds, renegotiation, liability, guarantees, and related matters shall survive the termination of this Agreement for the period of years set forth therein. If at the termination of this Agreement the Operator seeks to continue Mining at this location, the Operator shall, in addition to all other requirements imposed by law, regulation and ordinance, agree to enter in negotiations on a new agreement with the Participating Local Governments. Owner may assign this Agreement, without the consent of the Participating Local Governments to a related company of Operator. A related company shall be a subsidiary or parent company of Operator or a sister company of Operator having the same ultimate parent company as Operator's parent company. The Operator may also assign this Agreement to a third party, other than a related company, subject only to submission to the Participating Local Governments of proof of the proposed assignee's financial capacity to assume all of the Operator's obligations hereunder. At a minimum, the assignee shall demonstrate compliance with Sec. 144.87 (2) (e), Wis.

Stats. Upon presentation of proof of financial capability, the Participating Local Governments shall not unreasonably withhold consent to assignment.

20. CLOSING PLAN

The Operator of the Mine, prior to commencing operation, shall file with the Local Impact Committee a copy of a closing plan for the Mine. The plan, at a minimum, shall contain a detailed finish grade plan and a landscape planting plan with types of vegetation indicated. In addition, the Operator shall provide a plan for future disposition of the land. These plans may be the same as those submitted to DNR.

After completion of the present planned Mine Operation, Kennecott will consider several options for disposition of Kennecott-owned property and facilities in Rusk County such as, continuing to maintain ownership, leasing portions to the Participating Local Governments for use as an Industrial Park, or selling the property and facilities. Prior to the sale to third parties of any property owned by Kennecott in Rusk County at this time, or the sale to third parties of any Kennecott-owned facilities or structures required for the Mine Operation, the Participating Local Governments will be given the first right of refusal based on the highest bid received. This excludes the internal transfer or assignment of property or facilities to a related company of Kennecott, which related company shall include a parent company, subsidiary company of Kennecott or parent or a company having a common parent with Kennecott. In the event of an internal transfer, the assignee will assume the obligations of the assignor.

The Participating Local Governments either jointly or individually will be given the first option or right of first refusal to match a bonafide offer to purchase the industrial site situated in the Active Mine Area, provided that in the Operator's sole opinion the separate sale of any portion thereof does not adversely affect the sale or value of other property owned by the Operator. Said individual site shall include, but not be limited by reference thereto, the following:

(1) An area of land whose approximate dimensions are: Commencing at the Northwest corner of the intersection of Jensen Road and S.T.H. 27, thence Northerly 1000 feet; thence Westerly 1500 feet; thence Southerly 1000 feet; thence Easterly 1500 feet to the point of beginning, including the Operator's water treatment facility, crushing and ore loading facilities and administration center, among other structures but not including any portion of the Open Pit Mine or waste rock storage area.

(2) The building formerly known as the "H & H Hauler's Building" plus adjacent land, five hundred (500) feet to its North, South and West and East to the right-of-way of S.T.H. 27.

(3) The building formerly known as the "Grow Cheese Factory," plus adjacent land of the Operator, sufficient in the area to meet minimal requirements for industrial use under the Rusk County Zoning Code.

In addition, the industrial site shall also include the railway Spur Line connecting the Active Mine Area with the main line of the Wisconsin Central, Ltd.

Prior to the sale or dismantling of any equipment or facilities on the mine site the Participating Local Governments either jointly or individually will be given the first option or right of first refusal to match a bonafide offer to purchase any or all of the equipment and facilities, provided that in

Kennecott's sole opinion the separate sale of a specific item does not adversely affect the sale or value of other items. The equipment and facilities include such items as the fencing, pumps, water treatment facilities, crushing equipment, electrical equipment, piping, building (temporary and permanent), the rail spur, and the railroad right of way east of S.T.H. 27.

In the event Kennecott sells any property, equipment, or facilities to another mining company Kennecott will transfer the Participating Local Governments' option or right of first refusal as part of the sale. If the property is not to be used again for mining, Kennecott will use reasonable efforts to help the Participating Local Governments in finding a purchaser for the property.

Prior to the sale of the industrial site at the N.W. corner of the intersection of S.T.H. 27 and Jensen Road, if extended westerly to the Flambeau River, or the sale or dismantling of any equipment or facilities identified above, the Participating Local Governments either jointly or individually shall be given the first option or right of refusal to lease the industrial site and some or all of the equipment and facilities. The lease agreement will state that the users of the property will not resist, delay or interfere with any future mining operation on property presently owned by Kennecott in Rusk County, will not file any complaints against Kennecott or successors who may buy the property with respect to development or operation of any mine facility on Kennecott's property, will vacate the premises, upon ninety (90) days written notice to be exercised at the Operator's sole discretion whether at or before the end of an express term of occupancy and that its operations on premises shall be such that it is capable of physically vacating the premises within such period, and will carry full liability insurance in an amount sufficient to satisfy Kennecott. If Kennecott elects to sell the industrial site along with other property owned by Kennecott, Kennecott will use its best efforts to provide the Participating Local Government or Governments who are leasing the property and/or equipment an opportunity to meet with the potential buyers to discuss for a period not exceeding 30 days any arrangement between the potential buyer and the Participating Local Government or Governments which would not affect the sale but could be satisfactory to the Government or Governments.

The Operator agrees to donate to the Participating Local Governments, subsequent to the reclamation of the site of the Mining Operation controlled by this Agreement, that parcel which it owns East of the main line of the Wisconsin Central, Ltd., South of Doughty Road and North of Jensen Road provided the Participating Local Governments agree that the users of the property will not resist or delay further development of the Flambeau Ore deposit and will not file any complaints against Kennecott or subsequent mining companies with respect to development or operation of a mining project because of the proximity, use or impact of the further development to the said parcel.

The Operator further agrees to lease to the Participating Local Governments the following parcels which it owns for $1.00 and other consideration.

(1) A parcel on the North side of the former "Sisters Farm," lying West of the Flambeau River, for use and development as an outdoor recreation area;

(2) River Frontage adjacent to the end of Blackberry Lane at the Flambeau River for park purposes.

The lease agreement will include the provisions identified above for the leasing of the industrial site.

The Operator, although recognizing the positive economic and social impacts which its Mine will make upon the community and the citizens represented by the Participating Local Governments, agrees to duly consider the potential of donating other real estate from its holdings adjacent to the Active Mine Area to one or more of the Participating Local Governments or, in other ways, of benefiting the community. The Operator, in its sole discretion, agrees to contemplate these potentials, for the purpose of promoting, after cessation of Mining Operations, the interests of the community in which the contemplated mine will be situated.

Except as provided in this Agreement, any party, their successors and assigns, who acquires all or a portion of the Kennecott property and facilities located in Rusk County, shall not be permitted to use the property and facilities in a manner inconsistent with Kennecott's obligations pursuant to this Agreement and all applicable Federal, State and local laws, and such party will not oppose Kennecott's sale of remaining properties and facilities, and such party shall assume responsibility for the following obligations: (a) environmental, (b) all obligations resulting from the use of the property and facilities subsequent to the transfer of the property and facilities from Kennecott to such third parties, and (c) damage or injury to Kennecott caused by such third parties who have acquired the property and facilities in the event such third parties interfere with or adversely affect Kennecott's closing plan facilities. Such acquiring parties will permit Kennecott, upon reasonable notice, to have full access to the property and facilities to facilitate Kennecott's compliance with its obligations pursuant to this Agreement and all applicable Federal, State and local law.

It is further understood that the reference in the paragraph immediately above to environmental responsibility shall be limited to the liability of a successor in interest for environmental damage which occurs from and after the date of its assumption of ownership and use as a result of said successor's use of a specified portion of the Operator's property. It shall not be interpreted as transferring or assigning to such transferee any of the Operator's environmental obligations under this Agreement or under Federal or State laws or regulations pertaining to the Operator's Mining Operation, closure of the mine or reclamation of the Active Mining Area.

21. MUNICIPAL NEGOTIATION AND RELATED PROFESSIONAL EXPENSES
The Operator shall reimburse the Participating Local Governments for municipal costs and expenses incurred by them during negotiations or as a result of the Operator's intent to locate a Mine in the Town regardless of whether the Mine actually is constructed or operated. While these funds may be used to hire professionals to assist in the negotiation process, the funds shall not be used to encourage, devise, initiate, continue or otherwise pursue legislation, rulemaking or litigation to prohibit the project. The costs and expenses to be defrayed shall be limited to the sum of $60,000.00 to cover such legal, engineering, per diem and related expenses as have already been incurred as of the date of this Agreement or are anticipated to be incurred by the municipalities. The Applicant shall provide this sum in equal portions to the Participating Local Governments within thirty (30) days of the date of executing of this Agreement by all parties.

22. MUNICIPAL LIABILITY
The Operator agrees to indemnify and hold harmless the Participating Local Governments, their officers, agents or employees from any and all liability, loss or damage the Participating Local Governments or their officers, agents or employees may suffer as a result of any claims, demands, costs or judgments against them arising in any way from negotiation of this Agreement, or from actions brought against the Participating Local Governments from persons suffering injury or property damage as a result of the transportation to the Active Mine Area and from the Active Mine Area by the Owner or Operator or the agents or contractors of either, construction, operation, maintenance,

closure and long-term care of the Mine, provided, however, such liability, loss or damage was not caused by the negligent or willful or wanton misconduct of the Participating Local Governments or their Town Officials or agents or employees. This Agreement to indemnify shall be for a period of 25 years. The Operator also agrees to support, defend and/or reimburse the Participating Local Governments for seventy-five percent (75%) of their respective reasonable legal expenses with regard to the above mentioned actions provided, however, such proceeding is not brought by any person or group of which any Participating Local Governments, Town Official or Member of the Local Impact Committee, or person negotiating this Agreement on behalf of the City, Town or County is a member or has given financial or legislative support of any kind to such person or group.

23. OPERATOR RESPONSIBILITY DURING OPERATION AND AFTER CLOSURE OF THE MINE

To evidence its commitment to long-term care of the Mine, as required under the Wisconsin Administrative Code, including subsequent amendments thereto, the Operator shall provide the Participating Local Governments with the following documentation:

a. After issuance of the mining permit by the DNR, but prior to commencing mining, a certification to the Participating Local Governments that a bond payable to the DNR in the amount required under NR 132 or other appropriate security as required by NR 132 has been secured.

b. Thereafter, the Operator shall annually certify to the Participating Local Governments that it is in compliance with NR 132, including any amendments thereto.

The Operator further agrees not to seek an exemption from NR 132.13(3) or (4) and to maintain the bond or other security in accordance with NR 132.13-(3) and (4) for thirty (30) years after closure which period shall commence 90 days after completion of the backfilling of the Mine, unless the Committee receives a copy of the request to be exempted and concurs in writing, with a DNR conclusion to grant exemption. Such concurrence shall not be unreasonably withheld.

24. RENEGOTIATION

At any time, after the DNR grants of a mining permit under NR132 Wis. Adm. Code to the Operator, the Participating Local Governments or Kennecott may cause this Agreement to be opened for renegotiation by serving a petition upon the other party alleging the existence of one of the following conditions, provided that said petition or petitions are based upon findings made by or statements contained within correspondence to or from persons possessing the professional expertise to make such findings or statements, including but not limited to attorneys, engineers and hydrogeologists.

a. A feasibility study or any engineering or financial report disclosing any significant adverse environmental or economic impact not contemplated at the time of negotiation of this Agreement which has the potential to cause significant damages to the environment and/or expand significantly the financial burdens of any of the Participating Local Governments.

b. Expansion of more than ten percent (10%) of the area disturbed by the Operation in the Active Mine Area by the Operator, or the intention by the Operator to expand the site beyond the particular design described herein or the acquisition whether by purchase or gift, by the Operator, of a significant amount of additional real property or interest in additional real property adjoining the real property acknowledged by the parties to be the site of the Mine at the time of execution of the Agreement.

c. The Participating Local Governments reserve the further right, not to be limited by or to be construed as falling under subparagraph a., above, to invoke their rights under NR 132 Wis. Adm. Code and Sec. 144.836, Wis. Stats., to provide comments or evidence to the DNR in any hearing or hearings on a mining permit application in the event all of the following conditions occur:

- There is a substantial change in any of the environmental or financial premises listed in Exhibit F, upon which the Agreement is based.

- The change will have a significant adverse effect on the Participating Local Governments or their residents or reduce the Operator's requirement to protect the environment below the requirements of federal and state statutes and regulations.

- The change is made between the time of execution of this Agreement and the DNR grant to the Operator of a mining permit under NR 132 Wis. Adm. Code.

If the above conditions all occur, the Participating Local Governments will also have the right to reopen specific affected provisions of this Agreement, with the exception of Paragraphs 27 and 31, for purposes of addressing such significant adverse effects. This right to reopen specific affected provisions of this Agreement, with the exception of Paragraphs 27 and 31 may also be invoked by the Participating Local Governments in the event that subsequent to execution, the Operator seeks to procure a waiver from or variance from any Wisconsin Administrative Code provision other than those identified in Exhibit G, which variance requests are acknowledged by these Participating Local Governments as having been made known to them prior to execution of this Agreement and as to which they have no objection. This right is reserved relative to variances pertaining to construction, operation and closure of the

Mine and only if such waiver or variance has an adverse effect on the local community or reduce the Operator's requirement to protect the environment. As is set forth with respect to renegotiation of the Agreement under sub-paragraph a., above, the Agreement reopening process shall be based solely upon findings made by or statements contained within correspondence to or from persons possessing the professional expertise to make such findings or statements, including but not limited to attorneys, engineers and hydrogeologists. In the event that the Participating Local Governments seek to invoke the rights set forth herein, prior written notice of the specific provision(s) as to which Agreement reopening is demanded or, alternatively, with respect to additional variance or waiver requests beyond those specified in Exhibit G, upon notice thereof from the Operator, prior notice as to the refusal to agree to said further waivers or variances beyond those expressed in Exhibit G and/or to the amount and time period of the performance bond shall be communicated to the Operator. In the event that reopening is demanded, it shall be with reference to specific clauses of the Agreement only. All rights, obligations and responsibilities of the Operator and Participating Local Governments not affected by said clauses shall continue in full force and effect.

d. If at any time the Mine ceases operations for longer than six months which cessation is not caused by a labor dispute, economic shutdown or force majeure.

e. In the event that uranium or thorium, or either of them, are discovered within the Mine site at levels above natural background which would render them to be merchantable and subject to possible mining by the Operator.

For the purposes of implementing this sub-paragraph, the Operator shall notify the Participating Local Governments upon its acquisition of information or formulation of an intent, either of which falls within the categories at a to e above.

Within thirty (30) days of receiving documented invoices, after entering into renegotiation of this Agreement, the Operator shall reimburse the Participating Local Governments for seventy--five (75%) percent of justifiable municipal costs and expenses incurred as a result of such renegotiations. Said costs and expenses may include but are not limited to: (1) attorney and consulting fees, (2) per diem costs of municipal officials and employees and (3) per diem costs of the Committee. Such reimbursements shall not exceed the cap of $5,000.00 unless another amount is specified within any renegotiated agreement. During any renegotiation proceedings initiated under sub-section a., above, and until the same are concluded, any item of the Agreement which qualifies under sub-section a., above is subject to renegotiation.

25. GRIEVANCES

The Operator shall respond, in writing, within thirty (30) days to any written grievance filed by Participating Local Governments' officials, relative to the operation, including during the initial construction phase.

26. ADDITIONAL INFORMATION

Before any operational plans for the proposed Mine are filed with the DNR, the Applicant shall provide the Local Participating Governments with the following information, which may be the same as that provided DNR:

a. The names, business addresses and telephone numbers of the corporation and its corporate officers, including the name of its parent corporation.

b. The names, addresses and telephone numbers of the legal agents for the corporations in a. above.

c. The business address and telephone number of the corporate office most directly involved with this proposed Mine.

d. Description of proposed site ownership.

e. Status of any other Rusk County mine sites under construction by the Applicant and locational information about them.

f. Reference from corporate bond counsel, if available.

g. Description of any civil criminal violations the Applicant has had within this State, with DNR or other state or local agencies or government.

h. Name of the responsible corporate officer for this proposed site, and names of attorneys and negotiators for the Operator, including their business addresses and telephone numbers.

i. Types of Ores which will be removed from the proposed Mine.

j. Estimated amount of Ore in tonnage.

27. CONDITIONAL USE PERMIT

This Agreement is contingent upon, and the parties obligations hereunder will not commence until, the occurrence of the acts or events set forth in a., b., and f., below, and is further subject to the understandings set forth in c., d., and e. below:

a. The issuance of a conditional use permit for the Mine as provided in Attachment H.

b. All Participating Local Governments providing adequate proof to the DNR in the form necessary to satisfy the Wisconsin Statutes and Administrative Regulations that the proposed Mine has all necessary local approvals from the Participating Local Governments.

c. That portion of the Comprehensive Zoning Code known as the Rusk County Mineral Mining Code, Secs. 6.3 to 6.11, inclusive, shall not be applicable to the Active Mine Area, Mine, Mine Operation and Railway Spur Line.

d. The County Shoreland-Wetland overlay zoning district is not applicable to the Active Mine Area, Mine, Mine Operation and Railway Spur Line.

e. The zoning of the Active Mine Area and Railway Spur Line shall be under the I-1 industrial classification in the County Comprehensive Zoning Code.

f. A representation shall be made by counsel for the Town of Grant that, in his opinion, a certain moratorium against mining adopted at the annual town meeting held on April 13, 1982, and that certain moratorium against mining adopted at the annual town meeting on April 12, 1988, as pertaining to the Mine which is the subject of this Agreement are void and unenforceable.

The above activities shall be provided in accordance and consistent with all applicable statutory provisions.

28. LIMITATIONS ON OTHER CONTRACTS MADE BY THE APPLICANT/OPERATOR

To minimize concerns of Participating Local Governments about future operational or organizational changes, the Applicant/Operator agrees that:

a. This Agreement may not be assumed by a third party unless such third party is financially capable and assumes all of the obligations of Owner hereunder.

b. The Owner may not transfer responsibility of ownership, possession or operation of the Mine to a third party unless the third party is financially capable and assumes all of the obligations of Owner hereunder.

29. ENFORCEABILITY OF THIS AGREEMENT IN THE EVENT THAT THE MINE IS NOT LICENSED

If, for whatever reason, a license is not granted by DNR to the Operator, its successors, or assigns to operate the proposed Mine, sections 21. and 22. only shall be enforceable against the Operator, and all other items shall become null and void.

30. RUSK COUNTY MINING IMPACT FUND

a. Each of the Participating Local Governments shall in each year the Mine is in operation apply for and retain all amounts to which each is entitled under Sec. 70.395, Wis. Stats.

b. Annually, beginning with the year in which Mine Operation commences and continuing during each calendar year of the Mine Operation, the Operator shall pay to each of the Participating Local Governments, whether each actually receives net proceeds first dollar tax shares under Sec. 70.395 (2) (d) 1. and 2., Wis. Stats., or not, the difference if the amount each Participating Local Government is entitled to receive for their use under Secs. 70.395 (2) (d) 1. and 2., Wis. Stats. is less than $100,000 (adjusted for inflation under Sec. 70.375(6) Wis.Stats.) in proportion to the number of tons of Ore shipped in the calendar year in question versus 300,000 tons. In the event, however, that the Operator ships more or less than 300,000 tons in the calendar year in question, it shall pay to the

Participating Local Governments $100,000, plus the inflation factor under Sec. 70.375[6], Wis. Stats., multiplied times a ratio whose numerator shall be the number of tons actually shipped and whose denominator shall be 300,000, less their first dollar payment entitlement, plus inflation factor for that calendar year. This annualized payment shall be subject to the minimum operations gross payment required under c., below. However, the Operator will not pay any portion of the difference which results from tax credits the Operator receives from payment of any new pre-operations tax payments which are required by new tax laws. For the purpose of this paragraph, it is assumed that the Operator will invoke its right to annex at least 15% of the mineable Ore body to the City of Ladysmith, thus making the City eligible for receipt of first dollar payments under Sec. 70.395 (2) (d) 2., Wis. Stats.

c. It is the Operator's intention to provide to the Participating Local Governments a minimum gross payment which shall consist of the first dollar payments, adjusted for inflation under Sec. 70.375 (6), Wis. Stats., which each is actually entitled to receive pursuant to Sec. 70.395 (2) (d) 1. and 2., Wis. Stats., to the extent that tax monies are actually generated from the net proceeds tax, in sufficient amounts so as to cause the specified first dollar payments or portions thereof to be made to the Participating Local Governments, and additional payments, to be provided directly by the Operator to them, resulting in a minimum gross payment by the Operator to the Participating Local Governments over the operating life of the Mine in the amount of $1,500,000.00, adjusted for inflation in accord with Sec. 70.375 (6), Wis. Stats. (1985-86) provided no actions are taken by the State of Wisconsin or the Participating Local Governments which prevent the Operator from Mining the Ore Body. This cumulative payment shall be in addition to and not in lieu of any other tax shares which each of or any one of the Participating Local Governments may receive pursuant to Sec. 70.395 (2) (d) 1m., or 5. or (g), or (h), Wis. Stats, except as otherwise provided herein at d., below. This cumulative payment over the operating life of the Mine shall constitute a minimum guarantee of first dollar payments only under Sec. 70.395 (2) (d) 1. and 2., Wis. Stats. In addition, said cumulative payment shall be made by the Operator to the Participating Local Governments whether or not one or more of them is ineligible to receive first dollar payments under Secs. 70.375 to 70.395, Wis. Stats., and whether or not said statutory sections and the Wisconsin net proceeds tax on mineral extraction, whether in its present form or as amended, remain law throughout the operating life of this Mine.

d. Commencing with the first full calendar year of Mine Operation and continuing for not less than four (4) years or until the last full calendar year of Mine Operation, whichever is later, the Operator shall guarantee to Rusk County payment of up to its maximum entitlement to tax proceeds under Sec. 70.395(2)(d)1m., Wis. Stats., should the actual tax proceeds entitled by the County from the State of Wisconsin thereunder be less than the maximum entitlement of the County in any or all of those years. This guarantee shall be conditioned upon and subject to the following qualifications:

(1) For each calendar year subject hereto, the guarantee payment shall be based upon the average yearly Comex price of copper for the year in question. In accord with the following chart, depending upon the average Comex copper price, should the County be entitled from the State an amount less than its maximum entitlement of $250,000.00, the Operator shall guarantee payment to the County in the

amount of $250,000.00 multiplied by the percentage listed opposite the copper price in question, as modified by the terms of (2), (3) and (4) below.

(2) The annual guarantee, as conditioned under (1) above shall be subject to the following multiplier: the sum arrived at under (1) shall be multiplied times a ratio whose numerator shall be the actual number of tons of Ore shipped from the Mine in the calendar year in question and whose denominator shall be 300,000 tons or Ore.

(3) From the net sum arrived at upon application of (1) and (2) above, there shall be deducted the actual amount of tax collections the County is entitled to receive from the State of Wisconsin under Sec. 70.395(2)(d)1m., Wis. Stats., for the calendar year in question. The resulting sum, subject to (4), shall be paid directly from the Operator to the County.

(4) The guaranteed payments determined under this paragraph shall be further adjusted for inflation in accord with Sec. 70.375(6), Wis. Stats.

COMEX COPPER PRICE

Cents per pound of copper	Percentage
Less than 65	0
65 but less than 70	20
70 but less than 75	40
75 but less than 80	60
80 but less than 85	80
85 or greater	100

The Operator further agrees that pursuant to Sec. 70.395(2)(d)5c, Wis. Stats., the Operator will make a one-time only construction period payment, and pursuant to Sec. 70.395(2)(dg), Wis. Stats., the Operator will deduct the gross amount of said construction period payment from its tax liability under Sec. 70.395, Wis. Stats., for other than the maximum amount of first dollar payments. The Operator will use its best efforts to distribute such tax credits to minimize the impact on the taxes the County is entitled to receive under 70.395(2)(d)1m., Wis. Stats.

e. The Operator, in its capacity as owner of the real property, in which the Mine is situated, shall exercise the right granted at Sec. 66.021, Wis. Stats., to petition to annex the following described property to the City of Ladysmith:

A parcel of land located in Sections 9 and 10, Township 34 North, Range 6 West, Rusk County, Wisconsin, described as follows:

Commencing at the northeast corner of the Southeast Quarter of the Northeast Quarter (SE¼-NE¼) of said Section 10, also being the point of beginning of this description; thence westerly along the sixteenth line to the West right-of-way line of the Wisconsin Central Railroad Ltd.; thence southerly along said west right-of-way line to a point approximately 1250 feet North of the south line of said Section 10, said point also being North 40,500 feet as based upon the Flambeau Mining Corp. mine coordinate system; thence West, assumed bearing, 900 feet along the mine grid line of North 40,500 feet; thence South 300 feet; thence West 400 feet; thence North 300 feet to the mine grid line of North 40,500 feet; thence West to a point approximately 1380 feet North of the south line of said Section 9 and 1300 feet West of the east line of said

Section 9, said point being more particularly described as North 40,500 feet and East 40,100 feet, mine coordinates; thence South 45° West approximately 980 feet to Section 404 of the Flambeau Mining Corp. Baseline; thence approximately North 45° West 860 feet along Section 404 of said Baseline; thence South 45° West 600 feet to the center of the Flambeau River; thence South 45° East approximately 800 feet to a point, said point being more particularly defined as North 39,500 feet and East 39,000 feet, mine coordinates; thence East approximately 500 feet to a point, said point being more particularly defined as North 39,500 feet and East 39,500 feet, mine coordinates; thence approximately North 45° East 425 feet to a point, said point being more particularly described as North 39,800 feet and East 39,800 feet, mine coordinates; thence East 625 feet to a point, said point being more particularly described as North 39,800 feet and East 40,425 feet, mine coordinates; thence South 300 feet to a point approximately 380 feet north of the south line of said Section 9 and approximately 1050 feet West of the east line of said Section 9, said point being more particularly described as North 39,500 feet and East 40,425 feet, mine coordinates; thence East to the east line of said Section 10, said course being more particularly described as East along grid line North 39,500 feet, mine coordinates; thence North along the east line of said Section 10 to the point of beginning.

The purpose of this requirement shall be to enable the City of Ladysmith to be deemed eligible for first dollar payments under Sec. 70.395 (2) (d) 2., Wis. Stats. said property description is presumed to contain at least fifteen (15) percent (%) of the mineable Ore body which is the subject of this Agreement. Should the description not contain 15% of the mineable Ore body, it shall be the sole responsibility of the Operator to prepare a legal description of real estate which contains that minimum % for purposes of annexation to the City.

f. For the purpose of applying c., above as concerning the attribution of the inflation factor against the minimum gross payment due to the Participating Local Governments, the following shall control. In a given calendar year, the base payment, defined as $100,000 multiplied by the number of local governments who are considered Local Participating Governments with respect to paragraphs a, b, and c of this section 30 in proportion to the number of tons of Ore shipped in the calendar year in question versus 300,000 tons (hereinafter "base payment"), shall have added to it the indexed amount calculated under Sec. 70.375 (6), Wis. Stats. For each calendar year in which a base payment is made, the appropriate indexed amount shall be added thereto. When the base payments made equal $1,500,000.00, the Operator shall have satisfied its obligation hereunder.

g. In addition to the above described payments from the Operator to the Participating Local Governments, in the event that the Operator fails to exercise its right at all or prior to the commencement of Ore extraction, as to annexation of land to the City of Ladysmith, for the purposes of application of paragraphs a., b., c. and f., the City of Ladysmith shall be considered to be a Participating Local Government and the minimum gross payment called for at Paragraph b. shall not be reduced due to the City's ineligibility to receive first dollar payments under Sec. 70.395 (2) (d) 2., Wis. Stats. However, the City of Ladysmith shall not be considered a Participating Local Government with respect to paragraphs a, b, c and f, of this Section 30 if the City does not approve an annexation requested by the Operator which includes at least 15% of the Mineral Ore Body. If the City of Ladysmith is not considered a Participating Local Government with respect to paragraphs a, b, c and f of this section 30, the minimum gross payment of $1,500,000 referred to in paragraphs c, f and o will be reduced to $1,000,000.00.

h. The Participating Local Governments may, at their sole discretion, waive all or any portion of the payments to such Participating Local Governments, which payments are required hereunder, if they determine that presently unanticipated benefits of mining will provide offsetting long-term benefits to their respective Participating Local Governments.

i. Funds received under this paragraph 30. shall not be used to devise, initiate, continue or otherwise pursue legislation, rulemaking or litigation to suspend Mining Operations.

j. It is further understood and agreed upon that as to payments called for under this Agreement which are in addition to and beyond those payments received by the Participating Local Governments through and under the net proceeds tax under Secs. 70.375 to 70.395, Wis. Stats., the said additional payments may be used by each Participating Local Government Unit in any governmental or proprietary manner which it may legislate and shall not be limited to Mining related purposes.

k. The Operator will use all reasonable efforts to support the Participating Local Governments to cause a change to Sec. 70.395 (2) (d) 1m. and Sec. No. 70.396 (1) Wis. Stats. to eliminate the requirement that the County use amounts received from the Net Proceeds Taxes for Mine related purposes or enable it and/or the City or Town to develop sinking funds from which to meet unanticipated local costs associated with the operation and closure of the Mine. In addition, the Operator will use all reasonable efforts to support the Participating Local Government's efforts to receive the full share of the net proceeds first dollar taxes which they are entitled to under Sec. 70.395(2)(d) 1 and 2 Wis. Stats., and will contribute 50% of the reasonable legal fees associated with such an effort up to a maximum of $25,000.00.

l. In the event that during the Mine Operation phase the Operator, for reasons unrelated to this Agreement, avails itself of its ability to submit a petition for annexation or if its land is subject to a petition of a third party for annexation to the City of Ladysmith, which petition is adopted by the said City and as a result of which annexation less than 15% of the mineable Ore body remains in the Town of Grant, the Operator, despite said Town's ineligibility to continue receipt of first dollar payments under Sec. 70.395 (2) (d) 2., Wis. Stats., shall continue to treat the Town as a Participating Local Government and the annual payment and minimum gross payment called for at paragraph b. and c. shall not be reduced due to the Town's ineligibility to receive first dollar tax proceeds.

m. The guarantees expressed in this section shall be binding against the Operator; provided, however, that no actions shall be taken by the State of Wisconsin or the Participating Local Governments which will prevent the Operator from mining the Ore body and shipping Ore from it. In the event of such action, during the pendency of the halt to the Mining and shipping of Ore, if it is temporary in nature or, if permanent from and after its inception, the guarantees shall be ineffective and not binding upon the Operator. As to Ore shipments made before and/or after such a halt, all responsibilities of the Operator under this section shall be met by it.

n. (1) Wherever, in b., c. and d., above, the words "entitled" or "entitlement" are used with reference to a conditioning of the Operator's guarantee of first-dollar payments, it is understood and agreed upon between the parties hereto that said words refer solely to circumstances in which either the State of Wisconsin or its local impact board refuse, in a given year, to appropriate to one or more of the Participating Local Governments all or part of their first-dollar payment entitlements under Sec. 70.395(1)(a)(2)(d)1. and 2. and (e) Wis. Stats., for failure of the local government in question to have used past first-dollar payments in a manner consistent with law or where Participating Local Governments have been required to return previously appropriated first-dollar payments to the State of Wisconsin. Only under these express circumstances shall the Operator's minimum gross payment guarantee be reduced and then only to the extent of the deficiency in entitled first-dollar payments received or retained in accord with Sec. 70.395(1)(a)(2)(d)1. and 2. and (e), Wis. Stats., which deficiency is caused by the non-appropriation of or return to the State of first-dollar payments by the Participating Local Governments in question.

(2) It is the further understanding and agreement of the parties hereto that Sec. 70.395(1), Wis. Stats., calls for the payment of net revenue taxes collected by the Department of Administration to the extent of the first-dollar payments or 60 percent of the total tax collected, whichever is greater, into the investment and local impact fund, from which, in turn, the Department of Administration, upon certification of eligibility, shall distribute first-dollar payment monies to the Participating Local Governments under Sec. 70.395(2)(d)1. and 2., Wis. Stats., adjusted for inflation under Sec. 70.395(1)(c), Wis. Stats., as modified

by Sec. 70.395(2)(e), Wis. Stats. Thus, should the Operator pay, in any given year of operation, less than the amount required to fully fund the maximum legal levels of participation by each of the Participating Local Governments in first-dollar payments, as determined with reference to Sec. 70.395(1)(a), Wis. Stats., the minimum gross payment over the operating life of the Mine shall not be reduced.

o. If upon the conclusion of the shipping of Ore from the Mine, the total of the annual base payments are less than $1,500,000.00, which is the required minimum gross payment under c., above, the Operator shall, within three (3) months next following the final yearly base payment, which consist of the underlying first-dollar payment and the Operator's guarantee payment, pay to the Participating Local Governments the difference between $1,500,000.00 and the total of the annual base payments made. Added to this payment shall be the inflation factor in accord with Sec. 70.375(6), Wis. Stats.

31. LOCAL GOVERNMENTS WILL NOT OPPOSE THE MINE

Except as provided herein, the Participating Local Governments and parties negotiating this Agreement agree not to oppose the Mine or to take any action which would serve to unreasonably delay the construction of the Mine. The Participating Local Governments also agree to take all action necessary to assure that the Applicant is able to obtain all approvals, permits, licenses and moratorium removals, which may be necessary to assure that the Mine can be constructed and is able to commence operation.

The local permits, approvals and licenses herein above referred to are expressly identified as follows: (a) The conditional land use permit to be issued by Rusk County pursuant to its authority under Sec. 59.97, Wis. Stats. (b) Building permits consistent with applicable state and local regulations as may be required for the erection for structures. (c) Sanitary permits under state and local regulations as may be required. (d) Ratification by the Town of Grant in accord with Sec. 59.97 (5) (e) 6., Wis. Stats., of that change in zoning district boundaries incorporated by reference in the conditional use permit set forth at (a) above. (e) In the event of annexation of a part of the real properties subject to this Agreement to the City of Ladysmith, ratification by the said City of the terms of the conditional use permit as governing its zoning control of the Operator's land use thereupon.

The moratoriums are certain moratoriums against Mining adopted at the annual town meetings held on April 13, 1982 and April 12, 1988 as pertaining to the Mine which is the subject of this Agreement. Counsel for the Town of Grant represents that it is not necessary to remove these moratoriums as these certain moratoriums are void and unenforceable.

As to the permits which may be required under sub-clause (b) and (c) above, upon compliance of the Operator with state and local regulations, both of a procedural and substantive nature, the requisite permits shall be granted by the Participating Local Government in control of the same.

This affirmation shall include any and all local permits, approvals, licenses and moratoriums necessary for operation of the Mine, but shall not include any state or federal permits required to be obtained by the Operator in connection with the Mine. It shall be the Operator's sole responsibility to ascertain the need for and to apply for and procure any such permits.

32. INAPPLICABILITY OF RUSK COUNTY MINERAL MINING CODE

a. That portion of the Comprehensive Zoning Code known as the "Rusk County Mineral Mining Code," which consists of

Sections 6.3 to 6.11 inclusive of the Comprehensive Zoning Code shall not be applicable to the Active Mine Area, Mine, Mine Operation, and railroad spur.

b. The County Shoreland-Wetland overlay zoning district is not applicable to the Active Mining Area, Mine, Mine Operation, and railroad spur.

c. Zoning of the Active Mine area and areas encompassing the railroad spur shall be I-1.

33. DEFAULTS

In the event either party is in default in the observance or performance of any of the covenants or obligations contained in this Agreement, the nondefaulting party may give the defaulting party written notice of the default specifying the details of the same. The defaulting party shall have two weeks to remedy any default in payment of monies or a reasonable time of not less than two months within which to remedy any other default described herein or to commence action in good faith to remedy such default. Unless the defaulting party shall so comply the nondefaulting party may pursue any remedy it may have in equity or at law. If the nondefaulting party obtains a judicial determination that this Agreement should otherwise be terminated because of such default, the defaulting party shall have a reasonable time of not less than two months after such determination within which to remedy such default or to commence action in good faith to remedy such default before any such termination may be declared.

34. ABILITY OF PARTICIPATING LOCAL GOVERNMENTS TO PARTICIPATE IN NR132 HEARING PROCESS

Nothing in this Agreement shall be interpreted as restricting or prohibiting the Participating Local Governments from participating in the DNR permit granting process, with respect to this proposal to mine, providing, in the course of such participation, input or evidence to be considered by the DNR in its review and permitting process under NR132 Wis. Adm. Code. The sole restriction imposed hereunder upon the Participating Local Governments, should they chose to so participate, is that they shall not, in the course thereof, renounce, repudiate, or reopen this Agreement or any other permits and local approvals granted by them hereunder, except as such right or option may be made available to them under Section 24.

35. DISPUTES

The parties will use their best efforts to resolve disputes arising over the interpretation of this Agreement. In the event of such disputes, the party noting the dispute shall give the other party written notice of such dispute. Upon receipt of such written notice, the party receiving the notice shall have thirty (30) days to respond in writing to the original party. Thereafter, the parties shall meet together in good faith and use their best efforts to resolve the dispute in question. Either party may, at its sole expense, invite third parties, including technical consultants and others, to comment upon the dispute and the other party shall give due consideration to such comments. If the parties have not resolved the dispute within ninety (90) days of the date of the first written notice of the dispute, or by a later date, if agreed upon by the parties, either party may pursue any remedy it may have in equity or in law.

36. INVALIDATION

Invalidation of any item of this Agreement by a court, except paragraphs 27, 31 and 32, shall not invalidate the remainder of this Agreement. Invalidation of either paragraphs 27, 31 or 32 shall invalidate the entire Agreement except paragraphs 21 and 22.

37. LAW

This Agreement shall be interpreted under the laws of the State of Wisconsin.

38. NOTICES

Unless otherwise dictated within this Agreement, either expressly or by reasonable implication, and unless otherwise dictated pursuant to state or federal laws, rules or regulations governing the instant Mining Project, notices required or deemed appropriate under the terms of this Agreement shall be provided in writing and served personally or by mail upon the following designated representatives of the parties hereto:

(1) Upon Kennecott Explorations (Australia) Ltd., at 1515 Mineral Square, Salt Lake City, Utah 84112, Attention: Project Manager - Flambeau.

With a copy to:

Kennecott, 10 East South Temple Street, Salt Lake City, Utah 84133, Attention: Assistant Chief Counsel.

(2) Upon Local Impact Committee, to the Chairman thereof.

(3) Upon Rusk County to the Chairman of the Board of Supervisors at the Rusk County Court House, Ladysmith, Wisconsin 54848.

(4) Upon the Town of Grant, to the Chairman of the Town Board.

(5) Upon the City of Ladysmith, to the Clerk-Administrator at Ladysmith City Hall, Ladysmith, Wisconsin 54848.

It shall be the responsibility of each of the Participating Local Governments to promptly advise the Operator of the names and addresses of their designated representatives, as changes in said positions occur, from time to time. Prompt notice of a change in its designated representative or representatives shall be given by the Operator to each of the Participating Local Governments and the Local Impact Committee, as well.

39. MODIFICATIONS

There shall be no modifications to this Agreement, except those which are mutually agreed to by all of the parties hereto in which are reduced to writing and executed with the same formality as this Agreement.

40. TITLES ARE ILLUSTRATIVE OF CONTENT ONLY

Titles to sections, paragraphs and/or other subdivisions within this Agreement are for illustrative purposes only and shall not be construed as limiting or expanding the intent of the substantive language set forth thereunder.

41. LEGAL AUTHORITY

This Agreement is entered into by the Participating Local Governments in accord with the authority granted to each such unit pursuant to Secs. 59.07, 59.97, 60.22, 62.11, 66.30, 144.838, 144.839 (laws of 1987-88, Wis. Stats).

42. DATE

This Agreement is dated as of the 1st day of August, 1988.

RUSK COUNTY

By John P. Kaiser

Melanie Meyer

TOWN OF GRANT

By

CITY OF LADYSMITH

By ______________________

KENNECOTT EXPLORATIONS (AUSTRALIA) LTD.

By ______________________

MASTER-jl

EXHIBITS

A. Plot Plan showing the Active Mine Area

B. Legal description of the land where the Mine is located

C. Map showing location of groundwater monitoring wells

D. Map showing Area covered by Well Guarantee

E. Map showing Area covered by Property Guarantee

F. Premises Used as Basis For Agreement

G. Waivers and Variances approved by Local Impact Committee

H. Conditional Use Permit

I. Letter dated July 13, 1988 from L.E. Mercando to W.G. Thiel with attached Kennecott letter dated July 12, 1988 regarding Two Tier Testing

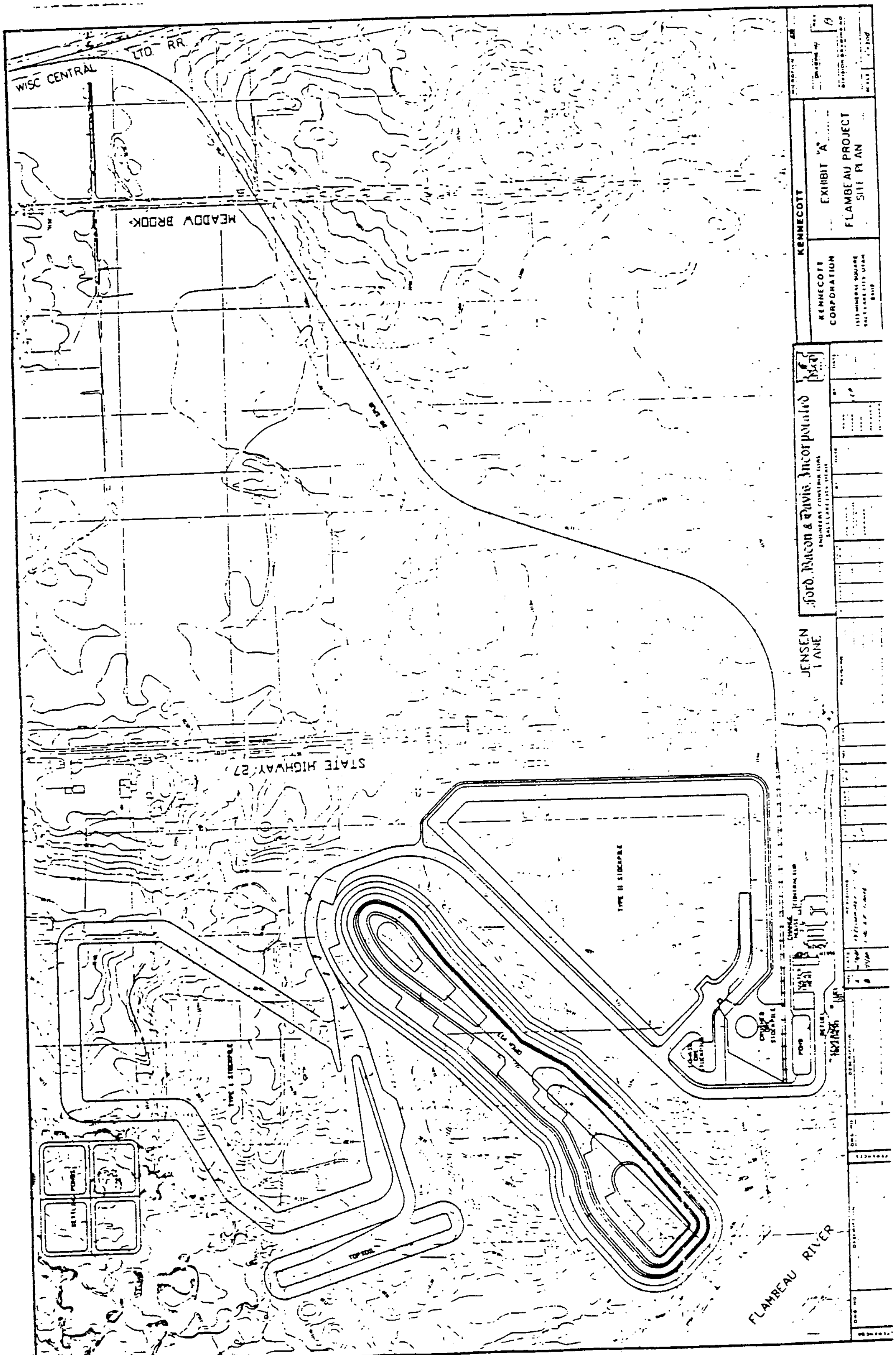

WISC CENTRAL LTD. RR.
MEADOW BROOK
STATE HIGHWAY 27
JENSEN LANE
FLAMBEAU RIVER
TYPE II STOCKPILE
TYPE I STOCKPILE
SETTLING PONDS
TOPSOIL
Ford, Bacon & Davis, Incorporated
KENNECOTT CORPORATION
KENNECOTT
EXHIBIT "A"
FLAMBEAU PROJECT SITE PLAN

EXHIBIT B

LEGAL DESCRIPTION OF THE LAND WHERE MINE IS LOCATED

FACILITIES ON LAND: Mine, appurtenant structures and facilities, but excluding the railroad spur, access roads, and utility feed lines.

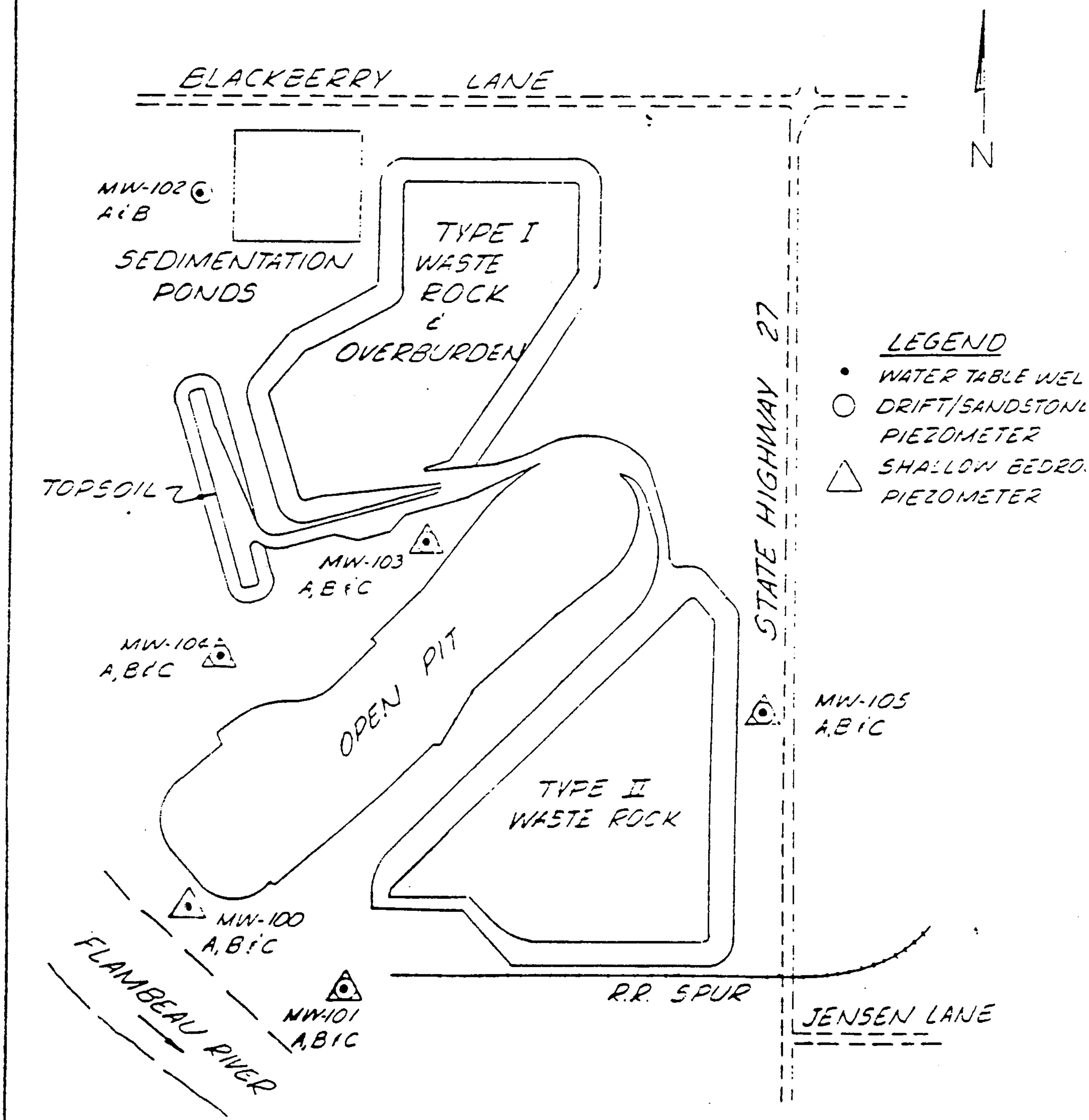
LEGAL DESCRIPTION: All that part of Section 9, Township 34 North, Range 6 West, Rusk County, Wisconsin, lying East of the Flambeau River and South of Blackberry Lane.

LEGAL DESCRIPTION OF THE RAILROAD SPUR

This permit also authorizes construction and operation of an approximately one mile long railroad spur to be located in part of Section 10, Township 34 North, Range 6 West, Rusk County, Wisconsin, lying west of the main line of the Wisconsin Central Railroad Ltd. as generally shown in the scale map of the site plan, Exhibit A.

It is understood by the County that until the DNR issues to the permit holder its NR132 permit, the legal description of the railroad spur line will be tentative only. It is possible that the DNR may approve of an alternate right-of-way, in which instance, without the need for further approval from the Zoning Committee, the official County zoning map shall be change to reflect the relocated railway right-of-way and its zoning district designated under Section (5) of this permit.

Kennecott is the legal and equitable owner of all of the above mentioned land.

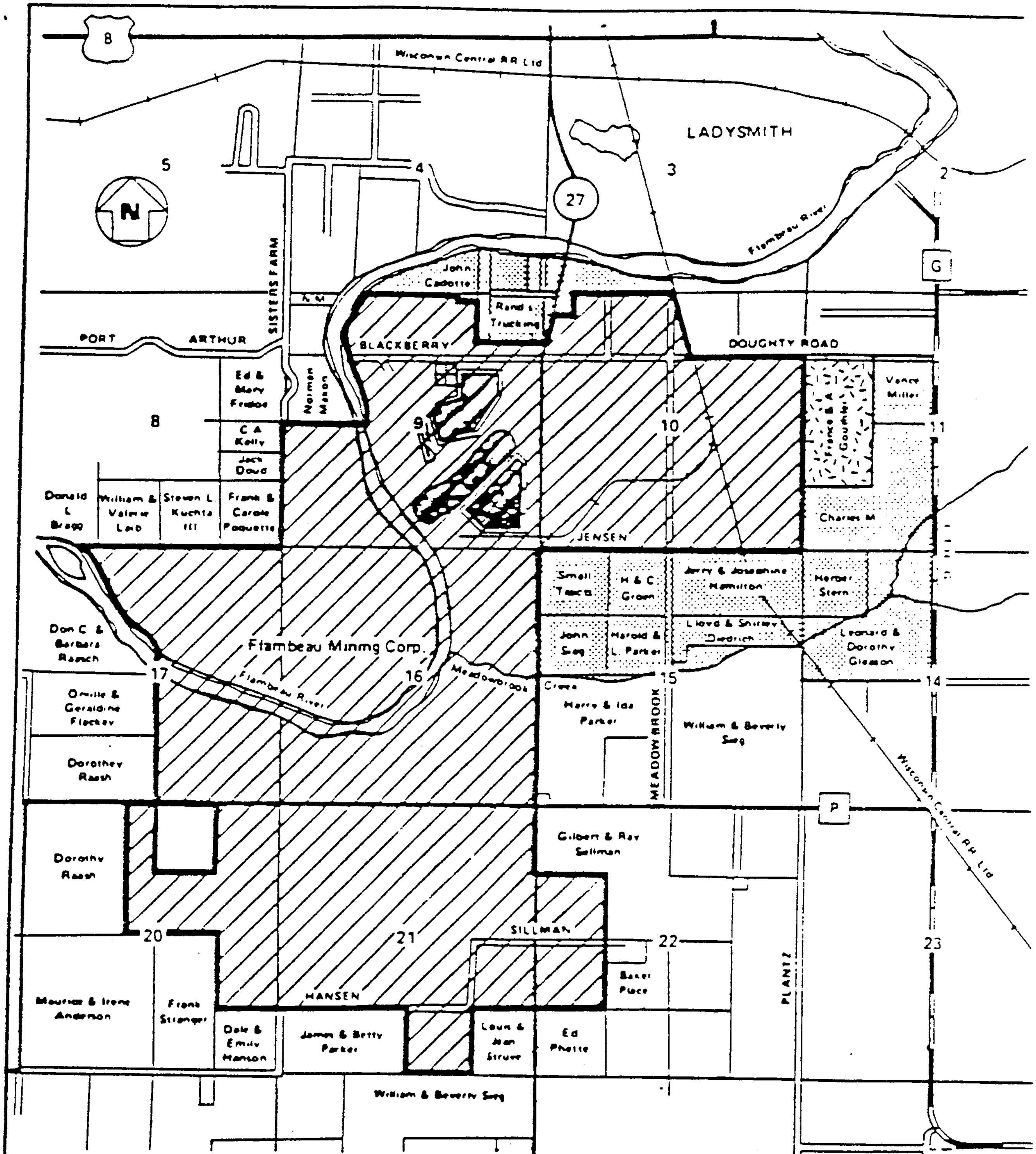


KENNECOTT FLAMBEAU PROJECT

EXHIBIT C
GROUNDWATER
MONITORING WELL LOCATIONS

SCALE: NONE | DATE 6-22-88

PREPARED BY FORD BACON & DAVIS, INC.



LEGEND

Kennecott Owned Property

City Water can be Provided

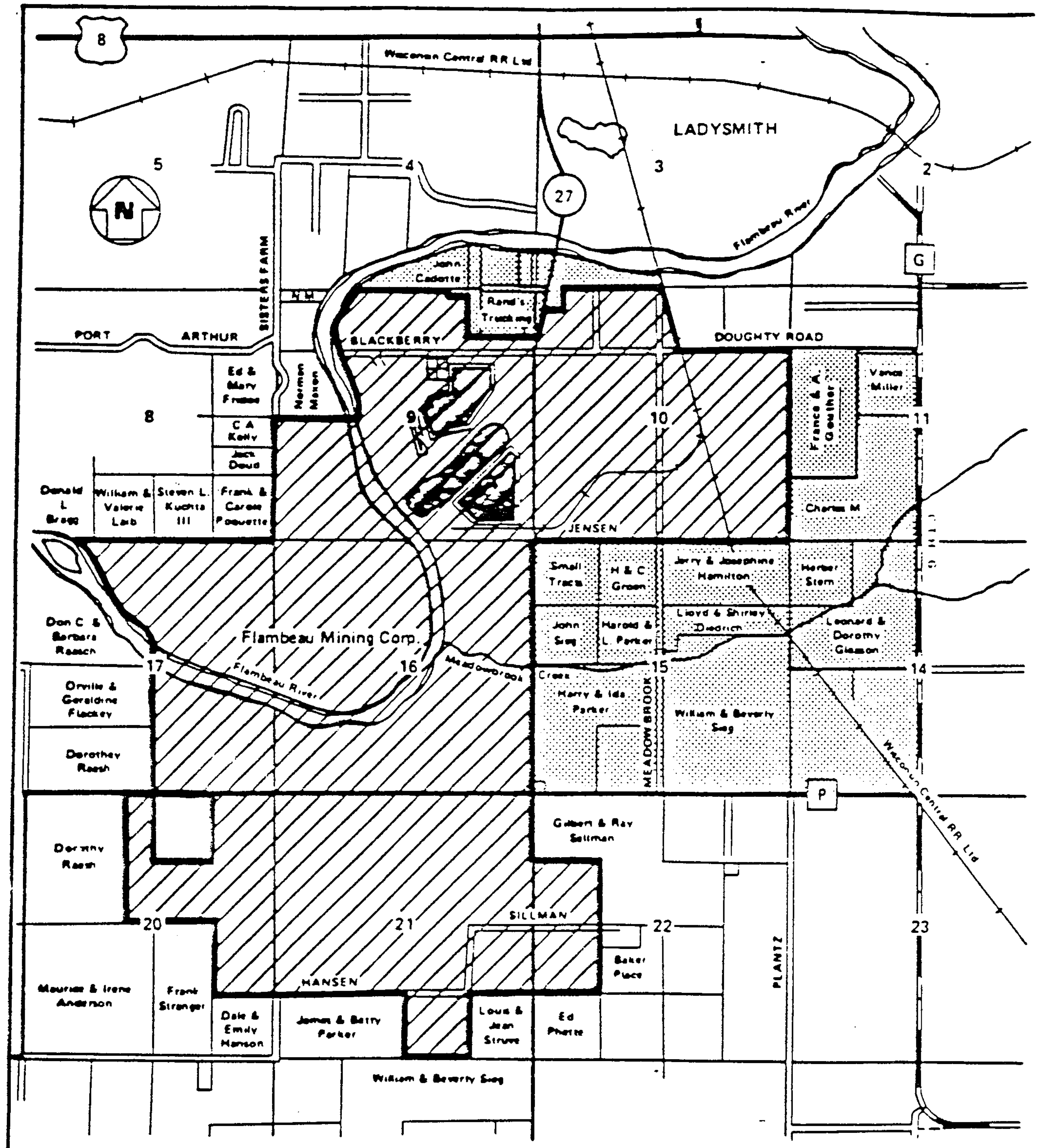
Areas to be Covered by Well Guarantee

EXHIBIT D

WELL GUARANTEE – LOCATION MAP

FLAMBEAU MINING COMPANY

June 1988



LEGEND

- Kennecott Owned Property
- Areas to be Covered by Property Value Guarantee

EXHIBIT E
LOCATION MAP
PROPERTY VALUE GUARANTEE
FLAMBEAU MINING COMPANY

June 1988

EXHIBIT F

PREMISES USED AS BASIS FOR AGREEMENT

1. Operation of the Mine shall comply with all DNR regulations in NR132 applicable to the Mine site and facilities except as exemptions from such regulations may be procured by Kennecott in accordance with NR132.19.

2. Operator shall take preventative measures to minimize surface water runoff or erosion by finish grading and seeding completed areas of the Mine in accordance with the closing plan made part of this Agreement.

3. The Open Pit shall be not greater than 40 acres, more or less, in size and shall be excavated to a depth of no more than 225 feet, more or less, below the grade existing on the site as of January 1, 1988.

4. The Open Pit Mine shall not be converted to a deep shaft mineral mine.

5. There will be no smelting, concentrating or refining of Ore on the Operator's land or in Rusk County.

6. The area disturbed by the operation in the Active Mine Area will not be expanded by more than 10%.

7. The Active Mine Area shall at all times during the construction, operations and closure phases of the project, be enclosed by the Security Fence, entry through which shall be via secured gates. The gates shall be closed and kept locked by the Operator except during the hours of operation.

8. Operator shall install, maintain and utilize surface water containment systems and a water treatment plant to protect the groundwater and surface water of Rusk County in accordance with DNR specifications.

9. The topsoil, waste rock and overburden removed from the Open Pit shall be stockpiled for use in site restoration during the Mine closure phase.

10. Primary means for transportation of Ore away from the site shall be via railroad and except as otherwise allowed in this Agreement, all transportation of Ore away from the site shall be via railroad.

11. Blasting, crushing and rail shipping operations shall be conducted during daylight hours, Monday through Saturday only.

12. The only non-hazardous wastes to be stored at the Mine are those mine wastes as defined by DNR and generated by the operations, except those materials necessary for operation of the Mine and facilities.

13. No Hazardous Waste, as currently defined by the DNR according to NR180.04(27) shall be accepted, received, stored, or disposed of or transported to the Mine. On-site storage of fuels, lab chemicals and blasting materials will be allowed provided they are contained in secured areas.

14. No less than six groundwater monitoring Well Clusters shall be constructed within the Active Mine Area. These wells are to be tested on at least a quarterly basis during the Baseline Monitoring Program, construction, and operation. Monitoring after closure shall be in accordance with the DNR approved reclamation plan.

15. During the life of the Active Mining operation and during any period of Temporary Closure, the Operator shall continued to collect, pump to its waste water treatment facility, and treat all waters which come into contact with sulfide mineralization which is of such characteristics so as to warrant treatment pursuant to NR132.

16. After issuance of the mining permit by the DNR, but prior to commencing mining a certification to the Participating Local Governments that a bond payable to the DNR in the amount required under NR132 or other appropriate security as required by NR132 has been secured.

17. The Operator agrees to maintain a reclamation bond or other security in accordance with NR132.13-(3) and (4) for thirty (30) years after closure which is 90 days after completion of the backfilling of the Mine unless the Committee receives a copy of the request to be exempted and concurs in writing with the DNR conclusion to grant exemption.

18. Environmental Premises.
    a. Operator will abide by all applicable federal and state laws, rules and regulations as to control, containment, elimination of or limitation of air, water, ground and noise pollution or contamination.

b. In accordance with the applicable federal and state laws, rules and regulations, it is the Opreator's intent to (i) protect ground and surface water resources from contamination which may arise in the course of the Mining Operation, that could result from contact by water with sulfide bearing rock formations associated with the mineral ore body to be mined, which protection shall take the form of collecting and treating surface, ground and precipitation water which may potentially be so contaminated before discharging the same onto the surface of the ground, into surface waters or into the ground; (ii) conduct its operations in all three (3) phases of the project in such a manner as to minimize adverse physical impact on land owners in the Town of Grant and City of Ladysmith; (iii) upon completion of mining, restore the site of the open pit, as nearly as possible, to its original grade by re-depositing, in the reverse of the order in which each such layer was removed, the waste rock, overburden and topsoil removed from the pit during the mining process and to re-vegetate the surface of the mine site; (iv) conduct blasting work in such a fashion as to minimize impact upon adjoining properties and improvements situated thereupon; (v) minimize dispersal of dust and/or other pollutants into the air in the course of Mining Operations and transportation of ore from the mine site; and (vi) retain fiscal and general management responsibility for site restoration, reclamation and environmental protection for a period of thirty (30) years next following the actual closure of the Mine.

EXHIBIT G

WAIVERS AND VARIANCES APPROVED BY LOCAL IMPACT COMMITTEE

NR132.18(1)(c)	-	The setback from the river will be 140 feet compared to 300 feet specified in the regulations. In addition, variances may also be required with respect to unnamed tributaries A, B and C in the Active Mine Area.
NR132.18(1)(d)	-	The proposed plan will require the construction of a dike which will partially be in the flood plain. The dike will provide additional protection against flooding of the mine during a 100 year storm.
NR132.18(1)(e)	-	The setback from the highway will be 150 feet compared to the 1,000 feet specified in the regulations.
NR132.18(1)(f)	-	A variance may be required with respect to the disturbance of several small wetland areas in the vicinity of the orebody.

APPENDIX C

Conditional Land Use Permit

CONDITIONAL LAND USE PERMIT

(1) GENERAL CONDITIONS.

Rusk County, a quasi-municipal corporation, duly organized under the laws of Wisconsin, hereby grants to Kennecott Explorations (Australia), Ltd., a Delaware corporation, the following Conditional Land Use Permit. Said permit is granted pursuant to the powers vested in Rusk County under Secs. 59.025, 59.07, 59.97 and 144.839, Stats., and constitutes an exercise of said county's authority to plan for and zone as to land uses within its corporate limits under the general auspices of its police powers. Said powers have been exercised in accord with Secs. 59.97, 66.30 and 144.839, Stats., and under the Rusk County Comprehensive Zoning Code, adopted April 20, 1971, as amended, from time to time thereafter, to and through the date of this permit. In addition, the Town of Grant, a civil town organized under the laws of Wisconsin, having, through its Town Board, elected to participate in County Comprehensive Zoning on or about June 14, 1982, and having elected to participate in the Local Agreement under Sec. 144.839, Wis. Stats., said Comprehensive Zoning Code and the exercise of County Zoning Powers as to the instant land use which is situated, either as a whole or in part, in the Town of Grant as of the date of issuance of this permit, is deemed to be effective under Wisconsin law.

This permit shall be interpreted and applied as a Conditional Use Permit, in accord with the definition of the term "conditional use" at Secs. 2.1(6) and 7.1 (Preamble) of the Rusk

County Comprehensive Zoning Code (hereinafter "Comprehensive Zoning Code"). As such, the Permit Holder shall strictly conform its activities and land uses to the terms of this permit.

Administration of this permit shall, at all times, be subject to the control of the Rusk County Zoning Committee, or its successor, a standing committee of the Rusk County Board of Supervisors, appointed pursuant to Sec. 59.06, Stats.

In accord with Sec. 59.97(1) and (11), and 144.839, Stats., the purpose of this permit grant shall be to promote the public health, safety and general welfare of the residents of the County, while at the same time allowing to the Permit Holder the right, subject to the limitations expressed herein, to engage in the described land use of property which it owns in Rusk County.

This permit implements a Local Agreement which was duly entered between Rusk County, the Town of Grant, the City of Ladysmith and Kennecott Explorations (Australia), Ltd., on August 1, 1988; and was duly approved of by the Rusk County Board on July 22, 1988, by the Ladysmith City Council on August 1, 1988, and by the Town Board of the Town of Grant on July 25, 1988.

(2) DEFINITIONS.

The following definitions, unless the context dictates otherwise, shall be used in interpretating and applying the provisions of this Conditional Use Permit:

(a) "Active Mine Area" shall refer to that real estate described at page 2 of the Local Agreement, whose legal description is as set forth at Sec. 3. of this permit.

(b) "Comprehensive Zoning Code" shall mean that code of ordinances duly adopted by the Rusk County Board of Supervisors pursuant to Sec. 59.97, Wis. Stats., et al., which generally governs, from a planning and zoning standpoint, the use of lands in unincorporated areas in said county in towns which have ratified said zoning code.

(c) "County" shall mean Rusk County, State of Wisconsin.

(d) "Disturbed Sites" shall mean any site which, during the course of construction, operation or closure shall have had its topography, surface grade and vegetation altered, removed, destroyed or disturbed, each of which site shall be within the Active Mine Area.

(e) "DNR" shall mean the Wisconsin Department of Natural Resources.

(f) "Local Agreement" shall mean that agreement entered into between Rusk County, the City of Ladysmith, the Town of Grant and the Permit Holder pursuant to Sec. 144.839, Wis. Stats.

(g) "Mining Activities" shall mean any and all land use activities engaged in under this permit related to a creation of, taking of ore from, and re-filling of the open pit to be situated on site and appurtenant activities and land uses associated therewith.

(h) "Mining Permit" shall mean the permit procured by the Permit Holder under Ch. NR132 Wis. Adm. Code.

(i) "Operator" shall mean the Permit Holder under this Conditional Use Permit.

(j) "Permit Holder" shall mean the individual or corporation or his or its assignee, transferee or conveyee operating subject to this Conditional Use Permit.

(k) "Stats." or "Wis. Stats." shall mean the Wisconsin Statutes.

(l) "Type I Wasterock" shall refer to that wasterock generated in the course of mining activities and removed from the open pit which does not contain an incidence of sulfide mineralization requiring storage and treatment in the same manner as Type II Wasterock so as to prevent water contamination. Type I Wasterock shall be backfilled, subject to DNR approval, into the mine during the closure phase.

(m) "Type II Wasterock" shall refer to that wasterock to be generated in the course of the mining activities and removed from the open pit which contains an incidence of sulfide mineralization sufficient to cause a leachate which requires treatment pursuant to DNR regulations. Such wasterock shall be stored in accord with the terms of the Local Agreement and backfilled, subject to DNR approval, into the mine during the closure phase.

(n) "Wis. Adm. Code" shall refer to the Wisconsin Administrative Code.

(o) "Zoning Administrator" shall mean that administrative official or employee of Rusk County, duly designated by the county board to administer its zoning code.

(p) "Zoning Committee" shall mean that standing committee designated by the Rusk County Board of Supervisors, within its realm of delegated authority, to administer the Zoning Code on behalf of the Board of Supervisors.

(3) LEGAL DESCRIPTION OF PROPERTY SUBJECT TO THE INSTANT PERMIT

All that part of Section 9, Township 34 North, Range 6 West, Rusk County, Wisconsin, lying East of the Flambeau River and South of Blackberry Lane.

This permit also authorizes construction and operation of a rail spur, approximately one mile in length, to be located in part of Section 10, Township 34 North, Range 6 West, Rusk County, Wisconsin, lying West of the main line of the Wisconsin Central, Ltd., as generally shown in the scale map of the site plan, Exhibit "A".

It is understood by the County that until the DNR issues to the Permit Holder its NR132 permit, the legal description of the Railway Spur Line as set forth above will be tentative only. It is possible that the DNR may approve of an alternate right-of-way, in which instance without the need for further approval from the Zoning Committee, the official County zoning map shall be changed to reflect the relocated railway right-of-way and its zoning district designation under Section (5) of this permit.

(4) PERMIT HOLDER.

The Permit Holder shall be Kennecott Explorations (Australia), Ltd., a Delaware corporation, or its successor in interest. The Permit Holder agrees and understands that the rights herein afforded to it are assignable or transferable only in accord with Sec. 19 of the Local Agreement. Upon any sale, transfer, lease or assignment of rights by the Permit Holder to a third party relative to the real estate subject hereto or of the transfer of rights or responsibilities relative to the commencement, continuation or closure of any operations maintained on said real estate in accord with this permit, all rights set forth under this permit shall then and there cease and be deemed unenforceable by the said transferee, assignee or conveyee, unless full compliance with the terms and conditions of Sec. 19 of the Local Agreement is demonstrated. All the terms and conditions of this permit shall be enforced against transferees, assignees or conveyees. The granting of this permit is based upon the underlying assumption that the Permit Holder qualifies to hold a mining permit under Sec. 144.85, Stats., continues to hold a valid mining permit thereafter and that, in the event of a sale, transfer or conveyance of the mine, that the proposed transferee, assignee or conveyee shall be in full compliance with Sec. 144.87(2), Wis. Stats. Should the DNR notify the Zoning Committee of a violation of said statute, it shall constitute cause for potential revocation of or the imposition of additional conditions hereupon in the discretion of the said committee in accord with Sec. (16) of this permit.

(5) ZONING CLASSIFICATION.

In accord with the Comprehensive Zoning Code, the zoning classification for the property described at Sec. (3), above, shall be that of the I-1, Industrial District.

(6) SETBACK REQUIREMENTS.

The following express setback requirements shall apply and pertain to land uses and the erection of structures upon the property described at (1), above.

(a) Subject to Department of Natural Resources of the State of Wisconsin (hereinafter "DNR") approval of variances under

NR132, Wis. Adm. Code, the following specific setbacks shall apply:

1. Highway setbacks from State Highway 27: 150 feet.
2. Setback from the Flambeau River; the minimum shall be as shown for the open pit on the scale map of the Active Mine Area shown in the site plan, Exhibit "A", which is 140 feet from the bank of the river as it existed on June 1, 1988.

In the absence of approval of said variances, the setbacks required under NR132, Wis. Adm. Code, shall be the minimum requirements to be met relative to the specific setbacks set forth above. Additionally, such other setbacks set forth at NR132 or variances therefore approved by the DNR, shall also apply. In addition, the following setback requirements shall be met: Setback from Blackberry Lane 63 feet from the centerline or 30 feet from the right-of-way line, whichever is greater. Minor, readily removable structures, such as open fences or signs may be placed within the setback lines. Public utility equipment without permanent foundations is also permitted. When deemed necessary by the Zoning Committee in conjunction with development, such as highway improvement programs, the Permit Holder and public utilities may be required to remove, at their own expense and without right of compensation, any such structures erected within the setback lines.

(b) In each quadrant of every street or highway intersection, there shall be designated a visual clearance triangle bounded by the street centerlines and a line connecting them 300 feet from any intersection with State Highway 27, and 200 feet from any intersection with Blackberry Lane. If two (2) highways of a different class intersect, the largest distance shall apply to both centerlines. Within this triangle, no object over 2 1/2 feet in height above the level of the streets shall be allowed if it obstructs the view across the triangle. Posts and open fences are excluded from this prohibition.

(c) Tree trunks shall be exempt from the visual clearance provisions set forth above when they are unbranched to a height of 10 feet and located a minimum of 30 feet apart.

(d) Where different from the setbacks identified at (a), above, as to the Active Mine Area, the setback from adjacent properties set forth at paragraph 4 of the Local Agreement shall control.

(e) With respect to both setbacks and site plan approval, the scale map of the Active Mine Area is incorporated herein by reference.

(f) In the event of any conflict between the setback requirements for purposes of procuring a mining permit, as imposed upon the Permit Holder by the DNR under NR132, Wis. Adm. Code, and those set forth herein, the more strict of said setback requirements shall be enforced, except in situations where the DNR has approved a variance.

(g) It shall be required of the Permit Holder that it shall, at its sole expense, survey, mark and delineate, by the placement of appropriate, permanent markers, each of the setback lines set forth above or incorporated herein by reference, with reference to highways, the Flambeau River and such other natural or artificial boundaries of the parcel subject to this permit as are required in order to demonstrate compliance with the setback conditions herein established.

(h) The setback requirements herein expressed shall not apply to the Railway Spur Line serving the Active Mine Area.

(i) The setback requirements set forth herein shall not apply to what is commonly referred to as the "old H & H Building," it having been located on the site subject hereto prior to the granting of this permit; provided, however, that said structure is hereby designated as a non-conforming structure. Structural repairs or alterations of it shall not exceed 50 percent of its assessed valuation as of the time it became non-conforming in June, 1982. In the event that use of the structure ceases for one (1) or more years, after ore shipment starts, it shall be considered to be abandoned and all use of it shall be permanently discontinued.

(7) FENCING AND SECURITY PROVISION REQUIREMENTS.

The Permit Holder shall, at all times, from and after commencement of construction of its mine site and appurtenant facilities, provide fencing of the Active Mine Area and/or security measures, consistent with the definition of "security fences" and Section 3(c)(4), Section 5, Sections 6 and 11(f) of the Local Agreement, each of which are incorporated herein by reference. This requirement shall apply solely with respect to the Active Mine Area. The Railway Spur Line need not be fenced outside of that location.

The maintenance of such fencing and security provisions shall be a condition of this permit to be observed at all times until the end of the reclamation period during the closure phase of operation by the Permit Holder.

(8) TRANSPORTATION RESTRICTIONS; ACCESS RESTRICTIONS.

The following restrictions, incorporated herein by reference from the Local Agreement, shall apply regarding transportation of ore from the Active Mine Area subject to this permit and, additionally, as to the means of access to and from the Active Mine Area.

(a) The primary means of transportation from the Active Mine Area shall be via railway, in accord with paragraph 10 of the Local Agreement.

(b) Emergency means of transportation: Availability of trucks for transportation purposes, to be limited by sections 10 and 11 of the Local Agreement.

(c) Access restrictions. The means of access to the Active Mine Area shall be limited as follows:

1. As set forth at sections 10 and 11 of the Local Agreement.

2. Construction of access driveways, streets or highways:

a. Shall be subject to town road standards as to construction, maintenance and repair.

b. Zoning Code Requirements Applicable. Access roads, streets or driveways constructed from the Active Mine Area to public highways abutting the land subject to this permit shall comply with the following requirements:

Highway:	Minimum Distance of Highway Frontage Between Access Roads:
State Highway 27	600 feet
Blackberry Lane	75 feet

The maximum number of access roads, driveways or streets connecting with each public highway abutting the Active Mine Area shall be two (2). This restriction, however, shall not prohibit the construction of an additional driveway from S.T.H. 27 to be used as access to a possible mine overlook for sightseers.

(9) PROHIBITION AS TO SMELTING, REFINING OR PROCESSING OF ORE.

There shall be no smelting, refining or processing of ore extracted from the subject mine, at any location within Rusk County, Wisconsin.

(10) PARKING AVAILABILITY.

As and for each building constructed under this permit, sufficient off-street parking spaces shall be provided for employee, agent and guest automobiles and trucks. Each parking space shall be at least 200 square feet in area. The actual number of spaces required shall be determined on the basis of projected office space and the number of anticipated employees and guests. Said determination shall be reviewed by the Zoning Administrator. In addition, the Permit Holder shall provide a sufficient area or areas within the Active Mine Area for storage of or parking of trucks, graders, earth moving equipment and other vehicles which may be used from time to time on the premises for purposes associated with the mining operation.

(11) LOCATION, HEIGHT, SIZE OF BUILDINGS AND OTHER STRUCTURES.

(a) To be limited to the approved site plan locations; subject, however, to the following understanding: the site plan incorporated herein by reference is preliminary in nature only. So long as both in number, size and location, structures which are ultimately built or constructed in the Active Mine Area do not substantially change the preliminary plan or substantially alter the scope of the project, changes as to structure locations shall be allowed without further approval of the committee. Any monitoring facilities mandated by the DNR are hereby approved and are not subject to these limitations.

(b) This permit shall include authorization to the Permit Holder to erect the following structures, each of which may exceed thirty-five (35) feet in height, but shall not exceed seventy-five (75) feet in height: Crushing facilities, stacker, ambient air monitors, storage piles, radio tower, water treatment facility and other structures as may be agreed upon by the Permit Holder and the County.

(12) INCORPORATION BY REFERENCE OF ALL APPLICABLE STATE AND FEDERAL REGULATIONS AS TO COMPLIANCE THEREWITH, SUBJECT TO EXPRESS VARIANCES, IF GRANTED, BY PERMIT AUTHORITIES.

The use of the Active Mine Area shall, in addition to being subject to the express terms hereof, be subject at all times to the application of all relevant state and federal regulations and strict compliance by the Permit Holder therewith, subject only to the exception of such express variances, if any, which are granted by the enforcement authorities. In the event the Permit Holder seeks a variance from any such regulation, it shall provide written notice to the Zoning Committee. In turn, the participating local governments could provide comments to or present evidence to the granting authority as to the appropriateness of the variance or variances requested. Variances which have been identified thus far are as follows:

(a) A variance from NR132.18(1)(d), Wis. Adm. Code as to the construction of a dike which would partially exist in the flood plain to provide additional protection against flooding of the mine during a 100-year storm.

(b) A variance from NR132.18(1)(f), Wis. Adm. Code as to the disturbance of several small wetland areas in the vicinity of the ore body.

(c) With reference to (6), above, as to setbacks, those specific variances sought under NR132.18(1)(e), and NR132.18(1)(c), as to setbacks from State Highway 27 and the Flambeau River and unnamed streams A, B and C.

This permit is further subject to strict compliance by the Permit Holder with all permit requirements imposed under NR132 and NR182, Wis. Adm. Code, as deemed to be applicable by the DNR and such other state and federal regulations and statutes governing mining, in general, and environmental controls of the state and federal governments as are incorporated therein by the State of Wisconsin by statute or Administrative Code provision or variances thereto.

(13) MINE WATER TREATMENT PLANT.

A mine water treatment plant, whose purpose shall be to treat ground and surface water and precipitation which comes in contact with sulfide mineralization sufficient to produce a leachate which does not meet with state discharge standards, during the course of operation subject to this permit, shall be constructed, maintained and operated by the Permit Holder, pursuant to and in accord with DNR regulations and requirements.

(14) BLASTING LIMITATIONS.

The following conditions and limitations shall apply to blasting and the use of explosives:

(a) Explosives shall be stored in strict compliance with all applicable state and federal laws and regulations, including but not limited to ILHR 7.20 to 7.23, Wis. Adm. code.

(b) No explosions shall be detonated except between 8:00 a.m. and 6:00 p.m., or between sunrise and sunset, whenever sunrise is later than or whenever sunset is earlier than the above designated times, Monday thru Saturday only.

(c) No explosions shall be detonated on the surface of the ground at the mine site, surface being described as the elevation of the ground as it existed on January 1, 1988.

(d) All explosions shall be detonated in such a manner as to control noise, particle displacement and ground vibration, and subject, specifically, to strict compliance with ILHR 7.64, Wis. Adm. code.

(e) Seismographic monitoring shall be required to be maintained in accord with ILHR 7.64 (4) (b) 3. and (d) 2., Wis. Adm. Code.

(f) No explosion shall be detonated which will result in a maximum peak particle velocity of the ground motion in any direction in excess of the standards at ILHR 7.64 (b) 1., Wis. Adm.

Code.

(g) In blasting, the Permit Holder shall at all times, comply with all applicable state and federal laws and regulations or variances therefrom.

(h) In accord with ILHR 7.37, Wis. Adm. code, the Permit Holder shall keep accurate records of times and locations of all explosions set off by it in the area covered by the permit as well as of the type and amount of explosive used for each hole, the size of the charge and the delay between charges. Said records shall be furnished to the Zoning Administrator upon request.

(i) For purposes of implementing this Conditinal Use Permit, the County hereby adopts by reference all other applicable provisions of ILHR 7, Wis. Adm. code, not expressly set forth herein, to the effect that ILHR 7 shall, in accord with ILHR 7.35 (2), Wis. Adm. Code, constitute a local regulation to be complied with by the Permit Holder. In accord with ILHR 7.35 (3), Wis. Adm. code, the site of the proposed blasting shall be considered to be in a "community", as defined at ILHR 7.04 (10), Wis. Adm. code, for purpose of requiring and implementing the notification provisions therein set forth.

(j) It is the further understanding of the Zoning Committee that the Permit Holder will be using a fertilizer base explosive consisting of ammonium nitrate and fuel -oil and/or dynamite and that use of the term "explosive" or any form thereof in this permit shall refer expressly thereto. Should the Permit Holder, at any time during the life of this permit, seek to change the type of explosives to be utilized, it shall first advise the Zoning Committee which shall not unreasonably withhold consent if compliance with all criteria of this portion of the permit shall, with such change, still be maintained.

(15) INSPECTION POWERS OF ZONING ADMINISTRATOR.

The County Zoning Administrator (hereinafter "Zoning Administrator") and his or her duly authorized agents shall have inspection powers and authority for the purposes of ascertaining compliance with the terms of this permit, which powers shall include but not be limited to the following:

(a) Access to any and all portions of the subject premises and any structure situated thereupon in order to perform his duties under the Comprehensive Zoning Code and this permit. The Permit Holder hereby consents to said entry between the hours of 8:00 a.m. and 6:00 p.m., Monday through Saturday, with the exception of legal holidays. At all other times prior arrangements shall be made with the Permit Holder by the Zoning Administrator for entry. In the event that the Permit Holder shall refuse a reasonable request for the right of entry, after reasonable notice, for any or no reason whatsoever, excluding reasons related to hazards, and for any or all of the purposes germane to and allowable under Sec. 66.122, Stats., the County and the Zoning Administrator may avail themselves of the right to obtain a special inspection warrant or warrants for inspection purposes.

(16) ENFORCEMENT OF ALLEGED VIOLATIONS.

(a) Included within this general category shall be:

1. Violations of the terms of this permit.

2. Violation of the terms of any state or federal

permit granted with respect to the mine.

3. Violation of any provision of the Comprehensive Zoning Code except that portion thereof designated as the "Rusk County Mineral Mining Code", Sections 6.3 through 6.11 inclusive of the Comprehensive Zoning Code, and any such other provisions of the Comprehensive Zoning Code which are inapplicable under the Local Agreement or are expressly or impliedly waived herein, if any.

4. Public nuisances constituting real and imminent dangers to public health, safety, and welfare created by operations maintained under this permit.

5. The building of, moving or substantial alteration of any structure (excluding removal) in the Active Mine Area which is not in substantial conformity with the approved of preliminary site plan incorporated by reference in this permit. This is subject, however, to the following understanding: The site plan incorporated herein by reference is preliminary in nature only. So long as, in number, size, location and degree of alteration, structures which are ultimately built or constructed during one of the three phases subject to this permit do not substantially change the preliminary plan or substantially alter the scope of the project, changes as to structure locations, construction or alteration shall be allowed without further approval of the committee and, hence, shall not constitute violations of this permit.

6. The use of any portion of the Active Mine Area which is not in substantial conformity with the approved site plan incorporated by reference under this permit.

(b) Remedies in the event of violations: Remedies may include, but not be limited to the following:

1. Temporary and permanent injunctive relief;

2. Damages, if any, sustained by Rusk County;

3. Imposition of a forfeiture in accord with (c), below;

4. Such other and further relief available to the County under Wisconsin law;

5. Revocation of this permit; or

6. The imposition of additional conditions not included in the original permit.

7. Relief with respect to items 1 - 4, above, may be obtained only through Court action.

(c) Forfeitures. Each violation of this permit and of the Comprehensive Zoning Code and of federal or state permits granted with respect to the contemplated mining operation shall be subject to the imposition upon the Permit Holder of a forfeiture in the amount of from $200.00 to $1,000.00 for each day that the violation continues, plus reasonable costs of prosecution should the County prevail. The period of time during which forfeitures may be assessable shall commence running with the first day after the end of the compliance period alloted to the Permit Holder pursuant to (d) of this section in the event that the Permit Holder fails to conform its land use activities to the directions of the County. In the event of a default in payment of any such forfeiture as assessed by a Court, unless a stay of payment is provided, the instant Conditional Use Permit shall be subject to termination at the discretion of the Zoning Committee. Each day a violation continues to exist shall constitute a separate violation. Resort to this remedy shall not be construed as limiting the County from resorting to any other remedies set forth at (b), above.

(d) Notices; Hearings; Right To Cure Performance.

1. Prior to instituting legal action, except as to public nuisances under (a)4., above, which are causing a real and imminent danger to public health, safety and welfare, the Zoning Administrator shall serve a written notice on the Permit Holder's designated representative of the nature of the alleged violations. The Permit Holder shall have 20 days to respond, either acknowledging the existence of the violations and setting forth its proposal to cure the same or expressly denying the allegations. In the event that the Permit Holder fails to respond or if its response is insufficient to cure the alleged violations, the Zoning Committee may authorize pursuit of a remedy or remedies under (b), above. Under no circumstances, however, shall the permit be revoked without the holding of a due process hearing. In the event that the Permit Holder's response to the notice is satisfactory, it shall be given a reasonable period of time by the committee in which to conform its land use activities to the terms of this permit. Should it fail to do so, the County may resort to the remedies at (b) above.

(17) PERMIT COVERAGE.

This permit shall cover the following phases of operation:

(a) Construction;

(b) Mine operation;

(c) Mine closure.

Subject to reopening in accord with (29), of this permit, this permit shall be valid for that period of time, commencing with the date of issuance hereof, defined further as that date no later than forty (40) days after ratification of this permit by the Rusk County Board of Supervisors or the date upon which the Town Board of the Town of Grant approves of the herein contained zoning district boundary change, whichever occurs first, in accord with Sec. 59.97 (5) (e) 6., Wis. Stats., and continuing for the duration of the three phases of operation as set forth above for a period not to exceed forty (40) years. The construction phase shall be first and its approximate duration shall be ten (10) months. Then shall follow the mine operation phase during which ore may be extracted and shipped and reclamation may begin and its approximate duration shall be five (5) years. Finally, the mine closure phase shall take place during which all reclamation and site restoration activities shall be completed, and, during which, environmental monitoring shall take place. In accord with the reclamation plan filed with and approved of by the DNR, during and immediately after the mine operation phase, the Permit Holder shall take the necessary steps to refill the open pit to the approximate grade which existed on June 1, 1988. The Permit Holder shall be required to complete its construction, mine operation and open pit refilling and site restoration activities within the first fifteen (15) years after the DNR has granted to it its NR132 permit. Should it be unable to do so, it shall be required to petition the County for an extension. Permission to so extend shall not unreasonably be withheld by the

Zoning Committee. Subsequent to the said fifteen (15) year period, or completion of pit refilling and site restoration, whichever occurs first, environmental monitoring shall continue for the remainder of the permit life or until concluded, whichever occurs first. Unless an extension of the permit life is requested as a permit modification under Sec. (29) of this permit, for mine closure purposes only, all special uses and entitlements under this permit shall cease at the conclusion of environmental monitoring or the passage of forty (40) years, whichever occurs first. Subject to the fifteen (15) and forty (40) year limitations, which shall be enforced, the time periods expressed herein for each phase shall be deemed to be approximations only. Nonetheless, once the shipping of ore during the mine operation phase has been concluded, the Permit Holder shall not be entitled to recommence the extraction and shipping of ore unless and until a renegotiated Local Agreement and modified Conditional Use Permit has been granted. The effective date, as expressed herein, shall be controlled by and subject to the provisions of (32), below.

(18) SIZE AND SCOPE LIMITATIONS.

This permit is conditioned upon the mine remaining within and not exceeding the limitations expressed at paragraphs 3.b. and c. and 24. of the Local Agreement.

(19) LIAISON TO THE COMMITTEE; REPORTS.

(a) The Permit Holder shall designate a qualified representative, familiar with all aspects of the mine, to act as a liaison to the Zoning Committee. His or her function shall be to respond to requests for information and to advise both the Committee and Zoning Administrator as to the status of the mining operation, from time to time. Said representative shall also be designated by the Permit Holder to receive written notices of alleged violations of this permit under Sec. (16) above.

(b) The Permit Holder shall provide to the Zoning Committee a copy of each report which it generates and provides to the Impact Committee under Section 16 of the Local Agreement.

(20) SITE PLAN.

Incorporated by reference in this permit is the Site Plan, Exhibit "A", of this permit and any monitoring facilities mandated by the DNR which are hereby approved of by the Zoning Committee. If, at any time during the life of this permit, the Permit Holder desires to substantially alter its site plan or erect additional structures beyond those identified on the site plan, incorporated herein by reference, which structures substantially vary in size, scope, height, number or use from those identified on the site plan, it shall first obtain approval of the Committee. In either granting or rejecting such alterations, the Committee shall be guided by Sec. 7.1 of the Comprehensive Zoning Code.

(21) PERMITTED USE.

This Conditional Use Permit grants to the holder the right to engage in mining activities in, upon and under the surface of the Active Mine Area, a special use. This permit also approves of the construction and operation of the Railway Spur, utility lines and access roads to serve the Active Mine Area. No other or further use of the real estate subject to this permit, not generally allowed as a permitted use under Sec. 14.5(a)(b), of the Comprehensive Zoning Code, shall be allowed.

(22) INAPPLICABILITY OF RUSK COUNTY SHORELAND-WETLAND ZONING PROVISIONS TO ACTIVE MINE AREA.

None of the property affected by this permit is within a shoreland-wetland district under the official Rusk County Shoreland-Wetland Maps as of the date of this permit. The Shoreland-Wetland overlay zoning district is not applicable to the Active Mine Area and land uses contemplated to be made of it under this permit. In accord with Sec. 14.8.3.C.2 of the Comprehensive Zoning Code, this permit shall control use of that portion of the Active Mine Area subject to the Shoreland Overlay Zoning District.

(23) INAPPLICABILITY OF RUSK COUNTY MINERAL MINING CODE.

Pursuant to the Local Agreement, Sections 6.3 through 6.11 inclusive of the Comprehensive Zoning Code, known as the "Rusk County Mineral Mining Code" shall not be applicable to the Permit Holder, nor to its land uses granted by this permit.

(24) REVEGETATION OF ACTIVE MINE AREA.

It shall be a condition of this permit that during the closure phase the Permit Holder shall re-vegetate all disturbed sites in the Active Mine Area. To facilitate such revegetation, the Permit Holder shall, prior to the construction phase, take an inventory of the existing vegetation. In revegetating disturbed sites the Permit Holder shall use said inventory as a guide and shall plant the same or similar grasses, shrubs, trees and other vegetation. Subsequent to said revegetation, the Permit Holder shall remain responsible for and shall insure viability of what it has planted for a period of 20 years, during which time it shall replant vegetation which fails to take hold and/or which dies.

(25) MODIFICATION OF PERMIT PROCEDURE.

In the event that subsequent to the issuance of this permit the Permit Holder desires modifications of the terms and conditions hereof including, but not limited to structural alterations, expansion of permitted uses or site plan amendments, the Permit Holder shall make an application to the Zoning Committee. In accord with Secs. 7.1 and 7.2(1), (3), (4) and (5) of the Comprehensive Zoning Code, the Zoning Committee shall issue its determination. In making such a decision, it shall not be bound by the Mineral Code, Sec. 6.3 through 6.11 inclusive, because those sections have been deemed inapplicable pursuant to the Local Agreement.

(26) FEES.

A. Upon ratification of this permit by the Rusk County Board of Supervisors, the Permit Holder shall pay a fee of $5,000.00, which fee shall be non-refundable and the purpose of which shall be to defray the costs of the permit granting process.

B. As a further condition of the permit, the Permit Holder shall make a contribution to Rusk County for the expenses to it of permit compliance monitoring and enforcement by the Zoning Administrator. Said contribution shall be in the amount of $750 per year. This requirement shall apply for each calendar year of construction and of mine operation. Said payment shall be made on or before December 31 of each calendar year of construction and of mine operation.

C. Upon application for modification of this permit, the Permit Holder shall pay a non-refundable fee of $500.00 and, additionally, shall pay all costs associated with the holding of the public hearing(s) and Zoning Committee meetings including, but not limited to per diems, costs of publication, expert witness and/or advisor fees.

D. The Permit Holder shall pay such other fees, charges and costs as are called for in this permit.

(27) PRECIPITATE DISPOSAL.

Precipitate, defined as any solid generated in the course of waste water treatment under Sec. (13) of this permit and further defined as the residue remaining after ground and surface water and precipitation which have come in contact with sulfide mineralization have been treated in accord with state water discharge standards, shall be disposed of as follows: The Operator shall store said precipitate in such a manner as to comply with Sec. (17) of the Local Agreement and shall, during or prior to the closure phase under this permit, re-deposit the said precipitate in the open pit, in conjunction with that portion of the Type II wasterock which has the highest incidence of sulfide mineralization, at the bottom of the said open pit, provided this method is approved of by the DNR.

(28) RAIL CAR AND TRUCK; ACCESS ROADS--DUST CONTROL.

The Permit Holder shall use appropriate means, consistent with Wisconsin law and regulations, to control dust from ore being transported by rail car or truck or from the passage of trucks over unpaved access roads.

(29) REOPENING OF PERMIT.

In the event that the Permit Holder desires to reopen and extend the life of this permit, it shall make application for the same to the Zoning Committee, in writing, at least two (2) years prior to the end of the term hereof. Reopening may be granted by the Committee solely for reasons related to site reclamation. In the event that the Permit Holder desires to expand or extend the project scope, whether during or after the mine operation phase, it shall be required to apply for a new permit in accord with Secs. 7.1 and 7.2(1), (3), (4) and (5), of the Comprehensive Zoning Code, or their successors.

(30) CLOSURE PHASE: MINE SITE RECLAMATION RESPONSIBILITY OF PERMIT HOLDER.

The Permit Holder shall remain financially responsible and shall, as such, maintain its reclamation bond or other security pursuant to NR132, WIs. Adm. Code covering the mine in question for a period of not less than thirty (30) years commencing 90 days next following the date and year of actual mine closure, unless the committee receives a copy of a request to be exempted and concurs in writing with the DNR conclusion to grant said exemption, such concurrence shall not be unreasonably withheld.

(31) SCREENING OF ACTIVE MINE AREA.

To the extent possible, consistent with the Permit Holder's use and erection of structures within and surrounding the Active Mine Area and the setback requirements herein set forth, in order to minimize traffic hazards along and upon S.T.H. 27, as it passes to the east of the Active Mine Area, caused by travelers upon said highway who wish to observe the Active Mine Area and, additionally, as an aesthetic component, the Permit Holder shall make reasonable efforts to retain the trees growing on its property adjacent to the west line of S.T.H. 27.

(32) AUTHORIZATION FOR CONDITIONAL LAND USE PERMIT.

The granting of this Conditional Land Use Permit to the Permit Holder by Rusk County, is authorized pursuant to Secs. 59.97 and 144.839, Wis. Stats., adopted in Act 399, Laws of 1987-88. It shall not be deemed to be effective, nor shall the Permit Holder consider it as conferring upon it any rights, entitlements or privileges until a public hearing has been held by each participating local government, as defined in the agreement incorporating this permit by reference, nor until each said unit of local government shall have, in open session, ratified entry into said Local agreement, nor until Rusk County, through its Board of Supervisors shall have ratified, in its capacity as the zoning authority, the granting of this permit. Only upon the occurance of the last of these events shall this permit be deemed to be effective.

(33) ADOPTION OF THE INSTANT PERMIT BY THE CITY OF LADYSMITH.

In the event that, in accord with the agreement incorporating this permit by reference, the Permit Holder annexes a portion of the property described at (1), above, to the City of Ladysmith, the said City hereby agrees, pursuant to the power vested in it at Secs. 62.23 (7) and 144.839, Wis. Stats., to adopt and implement the terms and conditions of this permit as its zoning regulation of the Permit Holder's mine.

(34) AMENDMENT OF TERMS AND CONDITIONS IMPOSED UNDER THIS PERMIT.

In the event that, during the period of time covered by this permit, the Permit Holder shall apply for variances from applicable federal or state laws or regulations, other than those identified at Sec. (12) above, which variances act to substantially change or have the potential to substantially change the nature of or scope or extent of the mining operations to take place in the Active Mine Area subject hereto, such as the development of a shaft underground mine or the installation of more or larger equipment so as to increase the yearly ore shipping rate in excess of 125 percent of the level expressed in Sec. 3.c. (10) of the Local Agreement or expanding beyond the limits of Sec. 24.b. of the Local Agreement, or in the event that cause exists, for either the Permit Holder or Rusk County to renegotiate all or a specific provision or provisions of this Local Agreement, in accord with Sec. 24 a., thereof, Rusk County reserves the right, in deference to the interest of the public health, safety and welfare and its authority at Sec. 59.97, Wis. Stats., to modify or impose additional or different conditions upon the Permit Holder's special use activity--mining. The process of considering and establishing or rejecting such additional or different conditions shall be governed by Sec. 7.1 and 7.2(1), (3), (4) and (5) of the Comprehensive Zoning Code or their successors.

(35) BACK FILLING OF OPEN PIT.

Upon the conclusion of its mining under this permit and under the Operator's NR132 permit, the Operator shall, in accord with and subject to applicable provisions of NR132 and NR182, back fill the open pit created in the course of its mining operations. The present plan, subject to DNR approval, is that it shall use the soil, overburden wasterock and precipitate generated from wastewater treatment in the back filling of the mine and shall deposit in the layer furthest below the grade level of the land that wasterock with the highest incidence of sulfide mineralization as well as the precipitate. It shall also, if acceptable to the DNR, and subject to engineering specifications approved of by the DNR, place at an appropriate level below the soil and overburden, a layer composed of a clay-like, possibly saprolitic rock formation, referred to otherwise as "ML material", to help assure that the permeability of the Type II Wasterock filled below the Type I Wasterock will be less than the permeability of the Type I Wasterock and earth fill at the top of the pit.

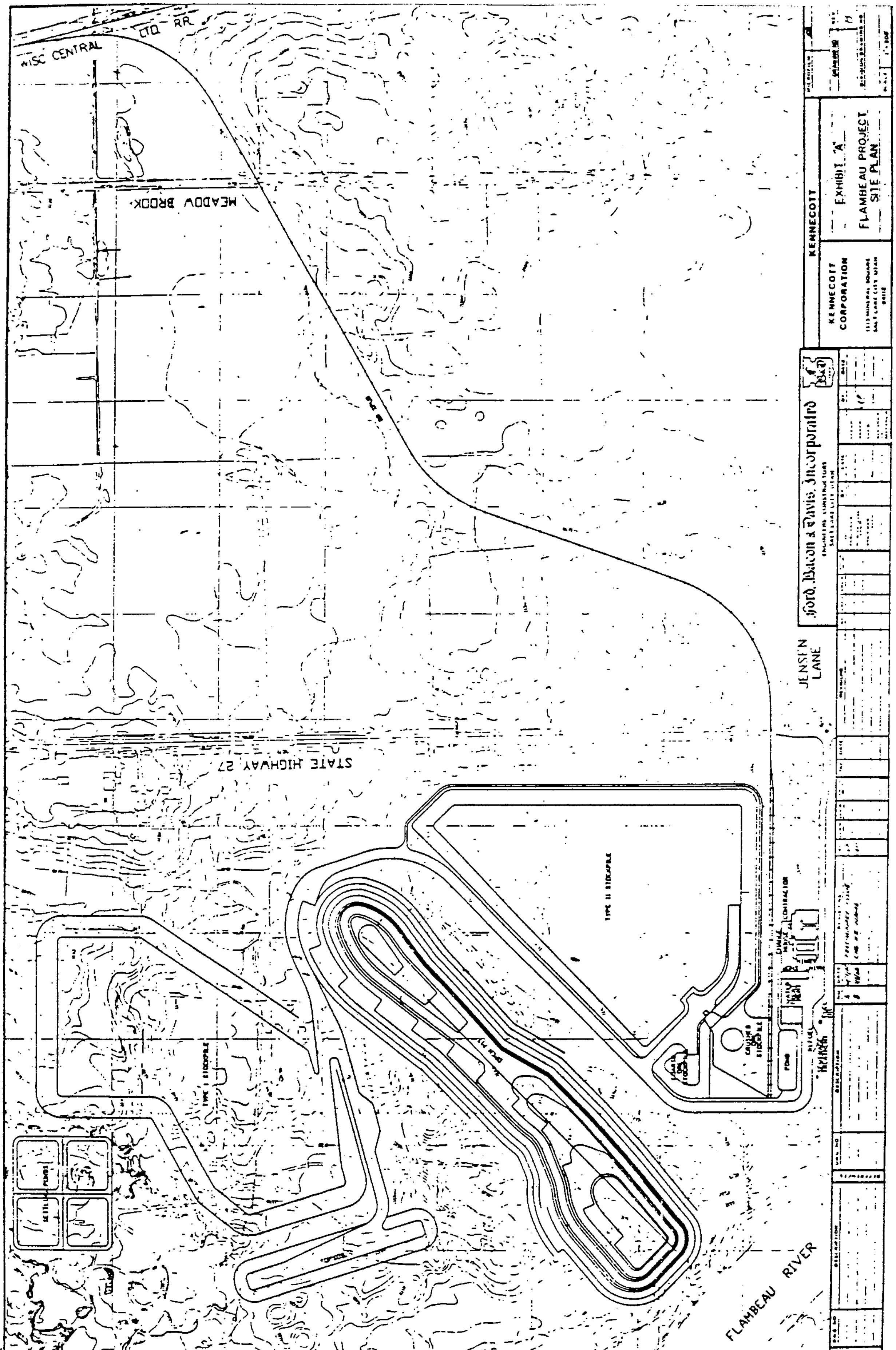
This Conditional Use Permit is hereby granted to the Permit Holder under authority vested in the Rusk County Board of Supervisors.

Rusk County,
A QuasiMunicipal Corporation of
The State of Wisconsin.

BY:

Norman Arndt

Norman Arndt
Zoning Administrator


WISC CENTRAL
CTO RR
MEADOW BROOK
STATE HIGHWAY 27
JENSEN LANE
FLAMBEAU RIVER
KENNECOTT
EXHIBIT "A"
FLAMBEAU PROJECT
SITE PLAN
KENNECOTT CORPORATION
Ford, Bacon & Davis Incorporated

APPENDIX D

Conditional Land Use Permit Certificate

RUSK COUNTY ZONING ADMINISTRATOR
COURTHOUSE
LADYSMITH, WISCONSIN 54848
TELEPHONE 532-2156

Permit No. 34
Date Issued 8-1-88

THIS CERTIFIES THAT A

LAND USE PERMIT

Has been issued to Kennecott Explorations (Australia) LTD.

Development of the

for Kennecott Flambeau Mine in
(Type and use of building) (Metes and bounds or Lot, block and subdivision)

As described in (3) of the Conditional Land Use Permit

in — ¼ of — ¼ of Section 9 in Township 34N Range 6W

on Hwy. "27" Highway Rusk County

Town of Grant Norman Arndt
(Zoning Administrator)

Post on Premises in Plain View

This permit also authorizes construction and operation of a rail spur, approximately one mile in length, to be located in part of section 10, township 34 north, Range 6 west. As per (3) Conditional Use Permit

APPENDIX E

Information Pertaining to Mining Bonds in Other States

Kennecott
10 East South Temple
P.O. Box [illegible]
Salt Lake City, [illegible]
(801) 322-7000

Kennecott

December 5, 1989

State of Wisconsin
Department of Natural Resources
Madison, Wisconsin

Gentlemen:

As Director, Treasury Services and in previous financial positions I have been involved in the insurance program for Kennecott for many years, including arrangements to provide surety bonds. In recent years our bonds have been provided by Aetna Casualty and Surety Company, The Insurance Company of North America and Safeco Insurance Company through Johnson & Higgins of Ohio, Inc. and Fred S. James & Co., Inc. of Nashville, Tennessee.

To the best of my knowledge Kennecott Corporation or its subsidiaries have never forfeited on a bond document during the past 20 years.

This information is provided to you in support of Section A10 of Mining Permit Application for Flambeau Mining Company, a subsidiary of Kennecott Corporation.

Very truly yours,

R B Kennedy

R. B. Kennedy
Director, Treasury Services

vr

APPENDIX F

Flambeau Mining Company
Financial Information

(Note: Financial Information Relating to Flambeau Mining Company Has Been Forwarded to the Wisconsin Department of Natural Resources Under Separate Cover).

APPENDIX G

Prediction of Chromium, Copper and Iron Concentrations in Vadose Zone Water Reaching the Water Table Beneath the Unlined Type I Stockpile for the Kennecott Flambeau Project, July 1989

PREDICTION OF CHROMIUM, COPPER, AND IRON CONCENTRATIONS IN VADOSE ZONE WATER REACHING THE WATER TABLE BENEATH THE UNLINED TYPE I STOCKPILE

Prepared for:

KENNECOTT MINERALS COMPANY

Prepared by:

FOTH & VAN DYKE and Associates, Inc.
2737 S. Ridge Road
P.O. Box 19012
Green Bay, Wisconsin 54307-9012

JULY 1989

Foth & Van Dyke
2737 S. Ridge Road
P. O. Box 19012
Green Bay, Wisconsin 54307-9012
414/497-2500

G1

Foth & Van Dyke
1989

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1.0 INTRODUCTION

An analytical plug flow model has been used to simulate unsaturated transport of leachate containing chromium, copper, and iron through the Type I stockpile and underlying till to the upper groundwater surface. A nine-foot thick layer of till will be placed beneath the base of the stockpile. This blanket will sorb, or retain, sufficient quantities of chromium, copper, and iron such that the concentrations of these metals within the leachate will not exceed the established enforcement standards. In addition, sorption or retention of these metals was modeled in the upper nine feet of the underlying till.

The effect of the metal sorption on the bulk composition of the till blanket will be nearly immeasurable. It will be possible to return the blanket material to the open pit during the backfilling process without degrading the site environment.

The impact upon groundwater from leachate from the Type I stockpile will be negligable. Concentrations of metals in the leachate reaching the groundwater will be similar to those already in the background groundwater. Therefore, no saturated contaminant transport modeling of the Type I stockpile leachate will be necessary.

2.0 METHODOLOGY

Type I wastes consisting of till, sandstone, saprolite, and waste rock, will be temporarily stockpiled above grade in an unlined forty acre site. The model described in this section was formulated in order to estimate the generation, transport, and reaction of the leachate generated by the hydration and hydrolysis of these waste materials. The leachate percolates through the unsaturated wastes and underlying till materials until it intersects and mixes with the saturated groundwater which is currently about 20 to 30 feet beneath the ground surface in the area. The output of the model is a time based estimate of the concentrations of chromium, copper, and iron in the leachate that enters the groundwater.

2.1 Model Inputs

The inputs to the unsaturated transport model include the quantity and type of waste material stored in the stockpile and the time during which the material is added to the stockpile. In addition, the quantity and periodicity of the precipitative inputs to the stockpile are utilized in the model. The reaction between the water intercepted by the stockpile with the waste generates the leachate which percolates through these materials to the groundwater. Reactions between the generated leachate and the underlying materials increases or decreases the concentrations of certain metals within the leachate and play a major role in determining the concentrations of these metals within the leachate that eventually reaches the groundwater.

2.1.1 Type I Waste Generation

Type I waste materials will be generated in two phases. The first phase, Phase I, will consist of wastes removed from the western half of the open pit. Phase II wastes will be subsequently removed from the eastern half of the open pit (see Table No. 4-2, KMINE). Phase I will consist of a preproduction and a production stage, relative to ore recovery. The preproduction stage of the first phase is expected to last six months. During this time period the till removed from the mine area will be used to make a "till blanket" of uniform thickness at the base of the 40-acre stockpile site. The till blanket will be made up from 7.78×10^5 tons of till which, when multiplied by the tonnage and swell factors (see KMINE p. 33), will create a blanket of 5.92×10^5 yds^3 that will have a uniform height of 9.2 ft. The blanket will be dimpled in its central portion in order to minimize runoff from the blanket and to maximize percolation of leachate through it.

Approximately 7.0×10^4 tons of the first sandstone removed will be used as a sand blanket in the drainage system in the Type II Stockpile. In addition, some till and/or sandstone will be used in the construction of roads at the mine site. With the exception of the sandstone that will be used in the Type II Stockpile, for the purposes of this model it will be considered that all of the remaining Type I wastes will be stored in the unlined stockpile.

The remaining Type I wastes will be stockpiled on top of the till blanket in segregated areas. The sizes of these areas were determined by calculating the volumetric proportion that each waste type would require to be stored on top of the till blanket so that a final uniform height of all of the adjacent units would be obtained. It is assumed that the stockpiled till will occupy the western 35 percent of the surface of the till blanket. Sandstone will occupy the northeastern corner of the blanket surface (18 percent of the total area), saprolite will occupy the east central part of the blanket surface (20 percent of the total surface area) and waste rock will occupy the southeastern portion of the blanket surface (27 percent of the total surface area). This stockpiling configuration was chosen in order to facilitate the backfilling of the open pit during reclamation activities. For purposes of modeling it is assumed that the borders of the till blanket and the stockpiled wastes will be at right angles with the horizontal surface (this greatly simplifies volumetric and areal calculations).

The production of each waste material by quarters of years of mine operation is included in Appendix A. The model assumes that each quarterly volume of waste added to the stockpile will be of uniform thickness.

A total of 9.07×10^5 yd^3 of till, 4.72×10^5 yd^3 of sandstone, 5.40×10^5 yd^3 of saprolite, and, 7.01×10^5 yd^3 of waste rock will be stockpiled on the till blanket. There will be 2.72×10^5 tons of blanket till beneath the stockpiled till, 1.40×10^5 tons of blanket till beneath the sandstone, 1.55×10^5 tons of blanket till beneath the saprolite, and 2.10×10^5 tons of blanket till beneath the waste rock.

2.1.2 Leachate Generation

The most important factor in leachate generation are the inputs of precipitation to the stockpiled wastes. Average monthly precipitation and temperature data corrected for losses due to evapotranspiration were added to the wastes on a quarterly basis (see KMINE, Appendix J, P. 28 for data). The quarters used in the model were January-March, April-June, July-September, and October-December. In the model it was assumed that the net precipitation was of uniform quantity during the entire quarter. Also, it was conservatively assumed that there was no runoff--that all of the net precipitation percolated through the waste and till blanket. The respective net precipitation numbers, in inches, used for the above-listed four quarters were 3.94, 3.30, 4.69, and 5.44, respectively.

The net precipitation that is introduced to the different wastes will percolate through them at different rates. It was observed during the wet/dry leaching tests performed as part of the waste characterization studies that the till and sandstone had drainage characteristics similar to a sandy loam. In addition, the saprolite had observed characteristics similar to a silt loam and the waste rock similar to a coarse sand. If it is assumed that the till blanket and stockpiled till, sandstone, and saprolite drain at a constant tension of -20 mb, and the waste rock at a constant tension of -40 mb, travel times for the leachate migrating through these materials can be estimated from published values for materials of similar drainage characteristics (see Bouma, *et.al.*, 1974). Therefore, leachate will migrate through the till and sandstone at the constant rate of 120 ft/yr, through the saprolite at the constant rate 16.8 ft/yr, and through the waste rock at the constant rate of 958 ft/yr. The calculated travel time for the generated leachate through the till blanket is 0.08 yr. Based upon the geologic sections depicted in Figure Nos. 3.5-4 and 3.5-9 of the KEIR, it appears that approximately 20 feet of till separates the base of the Type I stockpile from the groundwater surface. The computed travel time through this 20 feet for leachate is 0.17 yr. Therefore, the total travel time for water to leach to the water table through the till blanket and the underlying *in-situ* till will be 0.25 yr.

Wet/dry leaching experiments were performed on various waste materials as part of the waste characterization studies. These experiments simulate the reactions that will occur when precipitation reacts with the wastes. Mathematical relationships have been developed between the quantity of chromium, copper, and iron that will be leached from these materials and the leach cycle number (see Table Nos. 3.5-17 and 3.5-20 in the KEIR). These relationships are included in Appendix B. This information, combined with the net precipitation inputs, has been used to generate the quantity of leachate and the concentration of chromium, copper, and iron within that leachate for any of the waste materials. It is also possible to calculate the rate at which the generated leachate will migrate through the waste and underlying till on a quarterly basis.

2.1.3 Leachate Reactions with the Till Blanket

The reactions between leachate and the till blanket have been estimated from the soil sorption studies conducted as part of the waste characterization studies (see KEIR Section 3.5.6.3.4). Before direct use could be made of the experimental results, the iron concentrations had to be reduced so that the results would only reflect the reactions between till and dissolved iron in the leachate. The data modifications are included in Appendix C.

The results of the soil sorption studies indicate that the till will sorb, or retain, iron and copper, except at the lowest iron and copper concentrations at which the till will desorb iron and copper. The calculated distribution coefficients for these reactions at the highest concentrations of iron and copper used are 28.2 and 23.5 ml/g, respectively. These values are well within the range of coefficients determined for a wide range of soils (Baes and Sharp, 1983).

The leachate solutions were also analyzed for chromium. However, since most of the chromium concentrations were below the instrumental detection limit, no clear reactive relationship between chromium and the till could be determined. In the model, it was assumed that the reactions between the till and chromium were similar to that of the till with iron. This is a very conservative estimate, since trivalent chromium is more extensively sorbed than iron by most soils.

2.2 Model Outputs

The analytical plug flow section models of de Wit and van Keulen (1975) and of Frissel and Reiniger (1974) have been successfully used by Doran and Thresher (1986 and 1987) to simulate the transport of reactive leachates through unsaturated soils. These models very conservatively assume that there is neither dispersion nor retardation of the metals in the leachate as the leachate passes through the soil.

It was assumed that one significant leaching of the waste materials occurred during each quarter that the material was stored on the stockpile. It was also assumed that the generation of the leachate was instantaneous and therefore both the quantity of leachate and the concentrations of chromium, copper, and iron were constant during a given quarter. It was also assumed that only the till blanket and the upper nine feet of the underlying till would be involved in sorption/desorption reactions with the leachate.

The concentration of chromium, copper, and iron within the leachate that arrives at the till blanket was calculated by multiplying the quantity of a given waste which will be added to the stockpile in a given quarter by the quantity of chromium, copper, and iron that was predicted to be leached from that material. The concentrations of these metals in the leachate that finally arrives at the till blanket is a summation of the above products for each quarterly deposit of a given material.

The quantity of leachate and metal concentrations arriving at the groundwater surface at a given time is the proportionate summation of the net results of the till-reacted leachates from each of the waste materials. This is the basis for the development of the model output presented in Table No. 2-1.

TABLE NO. 2-1

Unsaturated Model Outputs

Time (yrs)	Leachate Volume L x 10^6	Metal Concentrations Chromium ug/L	Copper ug/L	Iron ug/L
0.00	22.4	0.5	10.0	56
0.25	16.2	0.5	10.0	56
0.50	13.6	0.7	10.3	112
0.75	15.8	0.5	11.3	60
1.00	26.5	0.5	33.6	56
1.25	19.5	0.7	30.2	56
1.50	15.6	0.9	28.5	56
1.75	15.4	1.0	31.5	58
2.00	19.9	1.3	38.4	67
2.25	21.5	2.5	27.5	102
2.50	17.4	2.3	22.6	245
2.75	14.1	2.6	18.0	204
3.00	18.4	2.2	19.6	166
3.25	20.6	2.5	14.6	172
3.50	16.8	1.6	14.2	115
3.75	15.4	1.3	17.0	82
4.00	18.7	1.1	20.9	72
4.25	20.6	1.4	16.3	92
4.50	16.8	1.0	16.2	71
4.75	15.0	0.9	18.3	63
5.00	19.9	0.9	18.7	61
5.25	21.8	1.2	15.8	73
5.50	16.2	1.0	14.2	60
5.75	13.9	0.8	12.5	56
6.00	18.2	0.8	10.4	56
6.25	21.8	1.1	10.0	61
6.50	17.4	0.9	10.0	56
6.75	14.1	0.8	10.0	56
7.00	18.2	0.7	10.0	56
7.25	21.8	0.5	10.0	56
7.50	17.4	0.5	10.0	56

3.0 SUMMARY AND CONCLUSIONS

The values presented in Table No. 2-1 indicate that only trace concentrations of chromium and minor concentrations of copper and iron will enter the groundwater beneath the Type I stockpile. None of the values exceed the MCLs for these compounds. Therefore, it is clear that, according to the standards set in NR 132 and NR 182, the Type I stockpile will cause no groundwater degradation.

The average quantity of chromium, copper, and iron in the till blanket is 7.30, 37.3, and 6090 tons, respectively (average of till-west and till-central values from Table No. 3.5-9, KEIR). If all the chromium, copper, and iron that will be leached from all of the Type I wastes (0.141, 2.04, and 9.02 tons, respectively) ends up being sorbed by the till blanket, the sorbed metals would only account for 1.9 percent, 5.2 percent, and 0.15 percent, respectively, of the total background contents of those metals in the blanket. The changes in the metals concentrations in the till blanket as a result of its reduction and retention of metals from the leachate would have no significant impact upon the bulk composition of the till blanket. Therefore, this blanket material can be returned to the pit during the backfilling process.

The quantities of chromium, copper, and iron that would be sorbed by the modeled nine feet of *in-situ* till underlying the till blanket will be 0.11 percent, 0.47 percent, and 0.01 percent, respectively, of the total bulk metal contents of the till. These increases in metal quantity are so low that they would not be measurable in the field.

The quantities of chromium, copper, and iron that would be sorbed by the modeled nine feet of *in-situ* till underlying the till blanket will be 0.11 percent, 0.47 percent, and 0.01 percent, respectively, of the total bulk metal contents of the till. These increases in metal quantity are so low that they would not be measurable in the field.

These results show that the leachate to be derived from the Type I stockpile will have no impact on groundwater upon reaching the water table. Even with the many very conservative assumptions that were made in this modeling effort, the model output shows that there will be no concentrations in the leachate which will exceed any applicable groundwater standards. The highest predicted chromium concentration is 2.6 ug/L, 5.2 percent of the MCL. The highest predicted copper concentration, 38.4 ug/L, is 3.8 percent of the MCL, and the highest predicted iron concentration, 245 ug/L, is 82 percent of the standard. Perhaps more importantly, the predicted concentrations for the three metals are roughly the same as, or even less than, the concentrations for the metals in the natural background groundwater.

Therefore, it must be concluded that no further saturated flow and contaminant transport modeling of Type I stockpile leachate is warranted.

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APPENDIX A

Production Schedule of the Type I Wastes

Note:

1. "SS" is sandstone, "ML" is saprolite and "I" is waste rock.

2. Production schedule computed by the firm of Pincock, Allen & Holt, Inc., Lakewood, Colorado.

Kennecott Flambeau Project
Mine Production Schedule - Type I Stockpile

Period	Phase	Bench	Till ktons	SS ktons	ML ktons	I ktons	Total ktons
PP	1	1130	48	0	0	0	48
		1120	115	0	0	0	115
		1110	235	0	0	0	235
		1100	245	71	0	0	316
		1090	104	118	36	0	258
		1080	27	34	134	0	195
		1070	4	0	55	0	59
			----	----	----	----	----
		Total	778	223	225	0	1226
1-1/4	1	1070	0	0	71	0	71
		1060	0	0	59	2	61
		1050	0	0	10	11	21
	2	1040	6	0	0	0	6
		1030	81	0	0	0	81
			----	----	----	----	----
		Total	87	0	140	13	240
1-2/4	1	1060	0	0	58	1	59
		1050	0	0	23	30	53
		1040	0	0	5	15	20
	2	1130	110	0	0	0	110
			----	----	----	----	----
		Total	110	0	86	46	242
1-3/4	1	1050	0	0	22	18	40
		1040	0	0	12	40	52
		1030	0	0	1	16	17
	2	1130	98	0	0	0	98
		1120	56	0	0	0	56
			----	----	----	----	----
		Total	154	0	35	74	263
1-4/4	1	1040	0	0	8	25	33
		1030	0	0	6	39	45
		1020	0	0	1	15	16
	2	1120	164	0	0	0	164
			----	----	----	----	----
		Total	164	0	15	79	258

Kennecott Flambeau Project
Mine Production Schedule - Type I Stockpile (Cont.)

2-1/4	1	1030	0	0	5	23	28
		1020	0	0	2	37	39
		1010	0	0	0	11	11
	2	1120	128	0	0	0	128
		1110	45	0	0	0	45
			----	----	----	----	----
		Total	173	0	7	71	251
2-2/4	1	1020	0	0	0	16	16
		1010	0	0	0	6	6
		1000	0	0	0	4	4
	2	1110	284	0	0	0	284
		1100	5	0	0	0	5
			----	----	----	----	----
		Total	289	0	0	26	315
2-3/4	1	1020	0	0	0	6	6
		1010	0	0	0	13	13
		1000	0	0	0	8	8
	2	1100	125	152	0	0	277
			----	----	----	----	----
		Total	125	152	0	27	304
2-4/4	1	1010	0	0	0	4	4
		1000	0	0	0	2	2
		990	0	0	0	3	3
	2	1100	20	30	0	0	50
		1090	37	212	6	0	255
			----	----	----	----	----
		Total	57	242	6	9	314
3-1/4	1	1000	0	0	0	9	9
		990	0	0	0	7	7
		980	0	0	0	3	3
	2	1090	12	65	1	0	78
		1080	15	89	39	0	143
			----	----	----	----	----
		Total	27	154	40	19	240
3-2/4	1	990	0	0	0	3	3
		980	0	0	0	7	7
	2	1080	8	47	20	0	75
		1070	4	0	42	0	46
		1060	0	1	27	7	35
			----	----	----	----	----
		Total	12	48	89	17	166

Kennecott Flambeau Project
Mine Production Schedule - Type I Stockpile (Cont.)

3-3/4	1	980	0	0	0	1	1
		970	0	0	0	8	8
	2	1070	1	7	22	1	31
		1060	0	1	27	7	35
		1050	0	0	13	28	41
			----	----	----	----	----
		Total	1	8	62	45	116
3-4/4	2	1070	2	2	18	0	22
		1060	0	0	18	5	23
		1050	0	0	11	23	34
		1040	0	0	0	45	45
			----	----	----	----	----
		Total	2	2	47	73	124
4-1/4	2	1050	0	0	6	10	16
		1040	0	0	1	43	44
		1030	0	0	0	46	46
		1020	0	0	0	12	12
			----	----	----	----	----
		Total	0	0	7	111	118
4-2/4	2	1030	0	0	0	39	39
		1020	0	0	0	68	68
		1010	0	0	0	7	7
			----	----	----	----	----
		Total	0	0	0	114	114
4-3/4	2	1010	0	0	0	47	47
		1000	0	0	0	45	45
		990	0	0	0	11	11
			----	----	----	----	----
		Total	0	0	0	103	103
4-4/4	2	1000	0	0	0	10	10
		990	0	0	0	50	50
		980	0	0	0	48	48
			----	----	----	----	----
		Total	0	0	0	108	108
5-1/4	2	980	0	0	0	5	5
		970	0	0	0	49	49
		960	0	0	0	25	25
			----	----	----	----	----
		Total	0	0	0	79	79

Kennecott Flambeau Project
Mine Production Schedule - Type I Stockpile (Cont.)

5-2/4	2	960	0	0	0	23	23
		950	0	0	0	9	9
			----	----	----	----	----
		Total	0	0	0	32	32
5-3/4	2	960	0	0	0	1	1
		950	0	0	0	6	6
		940	0	0	0	5	5
			----	----	----	----	----
		Total	0	0	0	12	12
5-4/4	2	950	0	0	0	2	2
		940	0	0	0	6	6
		930	0	0	0	2	2
			----	----	----	----	----
		Total	0	0	0	10	10
6-1/4	2	940	0	0	0	1	1
		930	0	0	0	6	6
		920	0	0	0	2	2
			----	----	----	----	----
		Total	0	0	0	9	9
6-2/4	2	920	0	0	0	2	2
		910	0	0	0	0	0
			----	----	----	----	----
		Total	0	0	0	2	2
6-3/4	2	910	0	0	0	0	0
		900	0	0	0	0	0
			----	----	----	----	----
		Total	0	0	0	0	0
			====	====	====	====	====
GRAND TOTAL			1979	829	759	1079	4646

APPENDIX B

Mathematical Relationships between Quantity of Metals Leached and Leach Cycle Number

1. INTRODUCTION

a. Mathematical relationships between the quantity of chromium, copper and iron leached from waste rock, saprolite, sandstone, and till, and the wet-dry leach cycle number have been developed.

- The data from the waste rock sample (WR-1) were taken from TABLE NO. 3.5-20 (KEIR).

- The data for the saprolite, sandstone and till samples were taken from TABLE NO. 3.5-17 (KEIR).

- The waste rock and saprolite samples were composite samples which contained material from the entire mine pit area.

- The sandstone and till samples each consisted of material collected in the western, central and eastern parts of the mine pit area.

b. The equations developed from these relationships were used to generate the quantities of metals that would be expected to leach from the Type I waste materials for each of leaching cycles 1 through 28.

2. WASTE ROCK COMPOSITE

a. Chromium

All values of chromium within the WR-1 wet-dry leachate were below instrumental detection limits. It is assumed that chromium concentrations in the leachate that enters the groundwater beneath the stockpiled waste rock will be 0.5 ug/L.

b. Copper

The maximum copper concentration in the WR-1 wet-dry leachate was measured in the cycle 1 leachate. The quantity of copper leached from sample WR-1 decreased from cycle 1 through 16 following a negative power function:

$$\text{Cu leached (ug/g)} = 0.25(\text{cycle \#})^{-1.66}$$

$$r^2 = 0.90$$

c. Iron

The maximum iron concentration in the WR-1 wet-dry leachate was measured in the cycle 1 leachate. The quantity of iron leached from sample WR-1 decreased from cycle 1 through 16 following a negative power function:

$$\text{Fe leached (ug/g)} = 0.34(\text{cycle \#})^{-1.35}$$

$$r^2 = 0.77$$

3. SAPROLITE COMPOSITE

a. Chromium

The maximum chromium concentration in the saprolite wet-dry leachate was measured in the cycle 4 leachate. The quantity of chromium leached from the sample increased from cycle 1 through 4 following a positive power function:

$$\text{Cr leached (ug/g)} = 0.0014(\text{cycle \#})^{1.01}$$

$$r^2 = 0.87$$

The quantity of chromium leached from the saprolite sample during wet-dry cycles 8 and 16 was less than 6.0×10^{-4} and less than 4.0×10^{-4}, respectively.

Values of 3.0×10^{-4} and 2.0×10^{-4}, respectively, were used for the quantities leached during these cycles. The quantity of chromium leached from the sample decreased from cycle 4 through 16 following a negative power function:

$$\text{Cr leached (ug/g)} = 0.0056(\text{cycle } \#)^{-1.13}$$

$$r^2 = 0.94$$

b. Copper

The maximum copper concentration in the saprolite wet-dry leachate was measured in the cycle 1 leachate. The quantity of copper leached during cycle 16 was determined to be less than 2.0×10^{-4} ug/g. A value of 1.0×10^{-4} ug/g was used for the quantity leached during cycle 16. The quantity of copper leached from the sample decreased from cycle 1 through 16 following a negative power function:

$$\text{Cu leached (ug/g)} = 0.37(\text{cycle } \#)^{-2.73}$$

$$r^2 = 0.79$$

c. Iron

The maximum iron concentration in the saprolite wet-dry leachate was measured in the cycle 4 leachate. The quantities of iron leached during cycles 1, 2 and 4 do not fit any simple mathematical relationship. If it is assumed that the quantity that would be leached during cycle 0 would be 0 ug/g, then a linear relationship can be used to approximate the changes in quantity leached between cycle 0 and 4. The approximated relationship used was:

$$\text{Fe leached (ug/g)} = 0.71(\text{cycle \#})$$

$$r^2 = 1.00$$

The quantity of iron leached during cycle 16 was determined to be less than 0.025 ug/g. A value of 0.0125 ug/g was used for this cycle. The quantity of iron leached from the saprolite sample decreased from cycle 4 through 16 following a negative power function:

$$\text{Fe leached (ug/g)} = 275(\text{cycle \#})^{-3.30}$$

$$r^2 = 0.99$$

4. SANDSTONE COMPOSITES

Approximately 25 percent of the sandstone will be removed from the west end of the pit (Phase I) and 75 percent will be removed from the east end of the pit (Phase II). The quantities of metals leached from the west and central composites were averaged in order to estimate the leachability of the Phase I sandstone. The central and east composite quantities were averaged in order to estimate the leachability of the Phase II sandstone.

The relationship developed to estimate the quantities of metals that would be leached from the entire mass of sandstone was formed by adding 25 percent of the west- central average quantities to 75 percent of the east- central average.

a. Chromium

The maximum chromium concentration in the west sandstone composite was measured in the cycle 1 leachate. The quantity of chromium leached from the west sandstone during cycle 8 was less than 5.0×10^{-4} ug/g. A value of 2.5×10^{-4} ug/g was used for the cycle 8 quantity. The quantity of chromium leached from this sample decreased from cycle 1 through 16 following a negative power function:

$$\text{Cr leached (ug/g)} = 0.055(\text{cycle \#})^{-2.04}$$

$$r^2 = 0.92$$

The maximum chromium concentration in the central sandstone composite was measured in the cycle 2 leachate. The quantity of chromium leached from this sample decreased, in general, from cycle 1 through 16 following a negative power function:

$$\text{Cr leached (ug/g)} = 0.0057(\text{cycle \#})^{-1.50}$$

$$r^2 = 0.82$$

The chromium concentrations in the cycle 1, 2 and 4 leachates collected from the east composite were nearly identical. No value was determined for the cycle 8 sample. The quantity of chromium leached from this sample during cycle 16 was determined to be less than 1.4×10^{-3} ug/g. It is assumed that the cycle 16 value for the central sandstone composite, 6.0×10^{-5} ug/g, would be similar to that of the east composite. Based upon this assumption, the quantity of chromium leached from the east composite sample decreased from cycle 1 through 16 following a negative power function:

$$\text{Cr leached (ug/g)} = 0.00067(\text{cycle \#})^{-0.74}$$

$$r^2 = 0.74$$

Cycle 1, 2, 4, 8, and 16 values for each composite were generated from the equations listed above. When the west and central values were averaged it was found that the quantity of chromium leached from the Phase I sandstone would decrease from cycle 1 through 16 following a negative power function:

$$\text{Cr leached (ug/g)} = 0.029(\text{cycle \#})^{-1.93}$$

$$r^2 = 1.00$$

When the central and east values were averaged it was found that the quantity of chromium leached from the Phase II sandstone would decrease from cycle 1 through 16 following a negative power function:

$$\text{Cr leached (ug/g)} = 0.0030(\text{cycle \#})^{-1.29}$$

$$r^2 = 1.00$$

Cycle 1 through 28 data were generated from these functions. The final values that were used in the model were formed by summing 25 percent of the Phase I values with 75 percent of the Phase II values.

b. Copper

The maximum copper concentrations in the west and central sandstone composites were measured in the cycle 1 leachate. The quantity of copper leached from these composites decreased from cycle 1 through 16 following negative power functions:

$$\text{Cu leached (ug/g)} = 0.61(\text{cycle \#})^{-1.83}$$

$$r^2 = 0.88\text{, and}$$

$$\text{Cu leached (ug/g)} = 0.012(\text{cycle \#})^{-1.12}$$

$$r^2 = 0.87\text{, respectively}$$

The maximum concentrations in the east sandstone composite were measured in the cycle 1 and 2 leachate. No values were determined for the cycle 8 and 16 samples. It is assumed that the cycle 16 value for the central composite, 3.7×10^{-4} ug/g, would be similar to that of the east composite.

Cycle 1, 2, 4, 8, and 16 values were generated for the east and central composites. These values, combined with the measured and estimated values for the east composite, were used to generate values for the Phase I and Phase II sandstone. The generated negative power functions for mining Phases I and II are:

$$\text{Cu leached (ug/g)} = 0.30(\text{cycle \#})^{-1.78}$$

$$r^2 = 0.99\text{, and}$$

$$\text{Cu leached (ug/g)} = 0.0070(\text{cycle \#})^{-0.99}$$

$$r^2 = 0.88\text{, respectively.}$$

Cycle 1 through 28 data were generated from these functions. The final values that were used in the model were formed by summing 25 percent of the Phase I values with 75 percent of the Phase II values.

c. Iron

The maximum iron concentration in the west sandstone leachate was measured in the cycle 1 leachate. The quantity of iron leached from this composite during cycle 8 was less than $1.0\text{x}10^{-2}$ ug/g. A value of $5.0\text{x}10^{-3}$ ug/g was used for the cycle 8 quantity.

The quantity of iron leached from the west sandstone composite decreased from cycle 1 through 16 following a negative power function:

$$\text{Fe leached (ug/g)} = 10.99(\text{cycle \#})^{-2.45}$$

$$r^2 = 0.79$$

The maximum iron concentration in the central sandstone composite was measured in the cycle 2 leachate. The quantity of iron leached from the central composite sample decreased from cycle 1 through 16 following a negative power function:

$$\text{Fe leached (ug/g)} = 2.55(\text{cycle \#})^{-1.99}$$

$$r^2 = 0.82$$

The iron concentrations in the cycle 1 and 2 leachates collected from the east composite were nearly identical. No value was determined for the cycle 8 sample. The quantity of iron leached from this composite during cycle 16 was less than 2.0×10^{-2} ug/g. A value of 1.0×10^{-2} ug/g was used for the cycle 16 quantity.

The quantity of iron leached from the east sandstone composite decreased from cycle 1 through 16 following a negative power function:

$$\text{Fe leached (ug/g)} = 0.19(\text{cycle \#})^{-0.76}$$

$$r^2 = 0.95$$

Cycle 1, 2, 4, 8, and 16 values for each composite were generated from the equations listed above. When the west and central values were averaged it was found that the quantity of iron leached from the Phase I sandstone would decrease from cycle 1 through 16 following a negative power function:

$$\text{Fe leached (ug/g)} = 6.63(\text{cycle \#})^{-2.31}$$

$$r^2 = 1.00$$

When the central and east values were averaged it was found that the quantity of iron leached from the Phase II sandstone would decrease from cycle 1 through 16 following a negative power function:

$$\text{Fe leached (ug/g)} = 1.21(\text{cycle \#})^{-1.61}$$

$$r^2 = 0.99$$

Cycle 1 through 28 data were generated from these two functions. The final values were formed by summing 25 percent of the Phase I values with 75 percent of the Phase II values.

5. TILL COMPOSITES

Approximately 40 percent of the till will be removed from the west end of the pit and 60 percent will be removed from the east end of the pit. All of the west end till and part of the east end till will be removed during the Phase I operations. For these reasons the quantities of metals leached from the west, central, and east composites were averaged to produce the values used in the model.

a. Chromium

The maximum chromium concentration in the west and east till leachates was measured in the cycle 4 leachate. The maximum concentration in the central leachate was measured in the cycle 2 leachate.

Three of the values, cycle 1 of the west till, cycle 8 of the central till, and cycle 8 of the east till were lower than instumental detection limits. The values used in the calculations were those of the detection limit since these values are very low.

The average quantity of chromium leached from the composites increased from cycle 1 through 4 following a positive power function:

$$\text{Cr leached (ug/g)} = 0.00094(\text{cycle \#})^{1.97}$$

$$r^2 = 1.00$$

An inspection of the plotted quantities of chromium leached versus leach cycle suggested that the quantities of chromium leached decreased linearly from cycle 4 through 16. A linear decrease was used in the model (values used to develop an equation describing the decrease were $1.4x10^{-2}$ ug/g at cycle 4 and $2.0x10^{-3}$ ug/g at cycle 20).

The values for the quantities of expected chromium that will be leached during cycles 1 through 28 were generated using the two equations listed above.

b. Copper

The maximum copper concentration in each of the till composites was measured in the cycle 1 leachates. The quantity of copper leached from these samples decreases in general from cycle 1 through 16.

The average measured quantities for cycles 2 and 8 appear to be low compared with those for cycles 1, 4, and 16. The average values for cycles 1, 8, and 16 were used to generate the estimated values for all of the 28 cycles. The equation generated from these data points indicates that the quantity of copper leached from the till samples decreases from cycle 1 through 16 following a negative power function:

$$\text{Cu leached (ug/g)} = 0.21(\text{cycle \#})^{-0.93}$$

$$r^2 = 0.90$$

c. Iron

The maximum iron concentration in the west till composite was measured in the cycle 8 leachate. The maximum iron concentration in the central and east till samples was measured in the cycle 4 leachates.

The maximum averaged quantity of iron leached from the till samples occurred during cycle 4. The quantity leached during cycles 1 through 4 increases following a positive power function:

$$\text{Fe leached (ug/g)} = 0.68(\text{cycle \#})^{2.05}$$

$$r^2 = 0.99$$

The quantity of iron leached from these samples decreases from cycle 4 through 16 following a negative log function:

$$\text{Fe leached (ug/g)} = 11.85\ln(\text{cycle \#})^{-3.48}$$

$$r^2 = 0.99$$

The values of the expected quantities of iron that will be leached from the till during cycles 1 through 28 were generated using these two equations.

APPENDIX C

Sorption of Iron by the Till Blanket

1. The values of iron concentrations in the equilibrating and final solutions in the soil sorption analyses for the till sample (see TABLE NO. 3.5-27, KEIR, p, 6.5-115) were reduced by 96% in order to obtain the actual dissolved iron concentrations in these solutions. The percentage reduction was calculated from the results of the bench studies performed during the design of the wastewater treatment facilities (see KPER, p.47).

2. The calculated gains (+) and/or losses (-) of iron by the till samples were corrected in order to reflect the reduction in dissolved iron concentrations. The revised data are:

Equilibrating Solution (ug Fe/L)	Final Solution (ug/L)	Soil Gain/Loss (ug/L)
376	156	+4.55
188	96	+0.79
94	92	0
37.6	68	-0.28
0	56	-0.51

APPENDIX H

Pipe Crushing Calculations

Ford, Bacon & Davis Incorporated

SUBJECT FLAMBEAU — SHEET -1 OF 3
JOB NO. M6033R102
LEACHATE COLLECTION SYSTEM — FILE NO.
BY [signature] DATE 11/2/89 CHECKED BY [signature] DATE 11/89.

CALCULATIONS DATED 3-27-89 INDICATE THAT A CLASS 200 PVC PIPE BE USED FOR 70 FT OF OVER BURDEN @ 190 PCF

THESE CALCULATION CHECK PIPE STRENGTH AND DEFLECTION FOR MIN. COVER AND A 48^K WHEEL LOAD.

FOR SIMPLIFICATION, THE 48^K LOAD IS TAKEN AS A CONCENTRATED (POINT) LOAD. THIS YIELDS CONSERVATIVE RESULTS.

RESULTS SUMMARY

FOR 2'-0" MIN. COVER OVER CLASS 200 6"Φ PVC PIPE

- TOTAL LOAD $= \frac{43.97}{.95} = 46.28$ psi << 92.36 psi @ 70' OVERBURDEN (see p. 2)
- $\frac{\Delta}{D} = 4.8\% < 5\%$ ∴ OK (see p. 3)
- EFFECT OF TRUCK LOAD BECOMES NEGLIGIBLE @ COVER HEIGHT OF APPROX. 8 FT.

CONCLUSION

DUE TO AVAILABILITY USE STANDARD (HEAVIER) ~ $\boxed{\text{SCH. 80 PVC PIPE}}$ WITH MIN. 2' COVER.
THIS MEETS REQ. OF ALL CRITERIA & PROVIDES ADEQUATE SAFETY FACTOR.

Ford, Bacon & Davis Incorporated

SUBJECT FLAMBEAU LEACHATE COLLECTION SYS

SHEET 2 OF 3

JOB NO. M60033R 102

FILE NO.

BY QB DATE 11/89 CHECKED BY [illegible] DATE 11/89.

CHECK CLASS 200 PIPE FOR LIVE LOAD

LOAD ON PIPE FROM TRUCK WHEEL @ 2' INCREMENTS

$W_{SC} = C_S P F'/L$ (EQ 16 REF. MANUAL)

C_S = LOAD COEFF. – TABLE 22, $B_c/2H$ & $L/2H$

(B_c = .5' $B_c/2H$ = .25/H) use L = 3' (max

DEPTH	$B_c/2H$	$L/2H$	C_S
2'	.125	.75	.124
4'	.0625	.375	< .05
6'	.0417	.25	< .02
8'	.0313	.1875	< .015

approximate

P = 48,000 lbs (CONCENTRATED LOAD)
F' = IMPACT FACTOR – USE 1.5 (Table 21)
L = 3' (MAX)

W_{SC} = LOAD ON PIPE / UNIT LENGTH

(2' DP) $W_{SC} = 48000(.124)(1.5)/3 = 2976$ lbs/FT OR 41.33 psi

NOTE wt SOIL w/ 2' COVER IS

$W_c = 2(190)(.5) = 190$ PLF OR 2.64 psi

TOTAL DL + LL = 43.97 < 92.36 psi (SEE CALC. 3-27-89)

∴ OK – Note 92.36 is stress @ 70' Cover. stress at 2' w/ 48^k is less ∴ OK

(8' DP COVER) $W_{SC} = 48000(.015)(1.5)/3 = 360$ lbs/Ft OR 5 psi.

$W_c = 8(190)(.5) = 760$ PLF OR 10.56 psi

TOTAL DL + LL = 10.56 + 5 = 15.56 psi < 92.36 psi

∴ OK

SUBJECT FLAMBEAU JOB NO. M6033R 102

LEACHATE COLLECTION SYSTEM FILE NO.

BY gB DATE 11/89 CHECKED BY cg DATE 11/89.

6" Φ CLASS 200 PIPE

CHECK % Δ IN PIPE WITH LIVE LOAD & 2' COVER

(IF LESS THAN 5% (.05) THEN OK)

(see attached p.136, HANDBOOK OF PVC PIPE)

$$\frac{\Delta}{D} = \frac{D_l KP + KW'}{[2E/3(DR-1)^3] + 0.061E'} \qquad \text{EQUATION 27}$$

P = PRISM LOAD = wH = 2.64 psi (page 1, w_c)

K = BEDDING CONSTANT = 0.1 (TYP. BEDDING CONDITION)

W' = LIVE LOAD = 41.33 psi

DR = SDR = 20.97 (p. 6 3-27-89 CALCS)

E = 4.2×10^5 PSI

E' = 1000 crushed Rock

D_l = DEFLECTION LAG FACTOR = 1.0

$$\frac{2E}{3(DR-1)^3} = \frac{2(4.2)(10^5)}{3(19.97)^3} = 35.16 \text{ psi}$$

$$\% \frac{\Delta}{D} = \frac{1.0(.1)(2.64) + .1(41.33)}{35.16 + .061(1000)} = \frac{4.397}{96.16} = .0457$$

REDUCTION FACTOR = .95 (SEE p 6 3-27-89 CALCS)

$$\frac{.0457}{.95} = .0481 \quad \text{OR} \quad 4.8\% < 5\%$$

∴ OK

NOTE: INFLUENCE OF TRUCK LOADS WILL BE NEGLIGABE AS DEPTH OF COVER APPROACHES 8'-0"

2'-0" MIN. COVER SHOULD BE PROVIDED.

FLEXIBLE PIPE THEORIES

Introduction. A flexible pipe may be defined as a conduit that will deflect at least 2 percent without any sign of structural distress such as injurious cracking. Although this definition is arbitrary, it is widely used.

A flexible pipe derives its soil load carrying capacity from its flexibility. Under soil load, the pipe tends to deflect, thereby developing passive soil support at the sides of the pipe. At the same time, the ring deflection relieves the pipe of the major portion of the vertical soil load which is then carried by the surrounding soil through the mechanism of an arching action over the pipe. The effective strength of the pipe-soil system is remarkably high. For example, tests at Utah State University indicate that a rigid pipe with a three-edge bearing strength of 3300 lb/ft (48.15 kN/m) buried in Class C bedding will fail with a soil load of 5000 lb/ft (72.95 kN/m). However, under the identical soil conditions and loading, PVC sewer pipe with a minimum pipe stiffness of 46 psi deflects only 5%. This deflection is far below that which could cause damage to the PVC pipe wall. Thus, in this example, the rigid pipe has failed but the flexible pipe has performed successfully, providing a factor of safety greater than 6:1. Of course, in flat plate or three-edge loading, the rigid pipe will support much more than the flexible pipe. This anomaly tends to mislead many would-be flexible pipe users because they relate low flat plate supporting strength for flexible pipe to the in-soil load capacity. Flat plate or three-edge loading is an appropriate measure of load bearing strength for rigid pipes but not for flexible pipes. See Figure 13 for typical pipe stiffness test results.

The inherent strength of flexible pipe is called pipe stiffness which is measured, according to ASTM D2412 Standard Test Method for External Loading Properties of Plastic Pipe by Parallel-Plate Loading, at an arbitrary datum of 5% deflection. Pipe stiffness is defined as:

EQUATION 18

$$PS = F/\Delta y \geqslant \frac{EI}{0.149r^3} = \frac{6.71EI}{r^3} = \frac{6.71Et^3}{12r^3} = 0.559E\left(\frac{t}{r}\right)^3$$

Where:
- PS = Pipe stiffness, Lbs/Lin•in or (psi)
- F = Force, lbs./lin. in
- Δy = Vertical deflection, in
- E = Modulus of elasticity, psi
- I = Moment of inertia of the wall cross-section per unit length of pipe, in^4/Lin. in. = in^3

APPENDIX I

Liner Efficiency and Leachate Head Calculations

Prepared by: JKS Date: March 27, 1989
Checked by: JWS Date: March 29, 1989

TABLE NO. 1

Liner Efficiency and Leachate Head Calculations

Approximate Slope (%)	Approximate Drain. Dist. L.F.	Approximate Base Area (%)	Efficiency (%)	Leachate Head (feet)	*T3
Phase I:					
1.18	396**	16.0	96.65	23.22	9.73
2.40	150	13.0	99.36	6.40	1.81
4.65	150	10.1	99.67	4.43	0.94
4.00	120	5.9	99.69	4.43	0.87
1.08	130	15.9	98.78	10.02	3.49
Phase II:					
1.74	110	13.9	99.36	6.42	1.83
0.67	200	25.2	97.01	20.97	8.66

* T3 is the time required to achieve steady state leachate head levels.

** Drain. Dist. of 396 feet is an average based on the shape and area (ft^2) of the Phase I area @ 1.18 percent slope.

NOTE:
1. Efficiency percentage, leachate head (feet), and T3 derived from Wong Equation. Refer to attached calculations.
2. Refer to Table No. 2 for annual infiltration (in.) utilized in the Wong Equation.
3. The liner permeability of 1×10^{-11} used in the Wong Equation is a conservative estimate based on information presented at the Eleventh Annual Madison Waste Conference (September 13-14, 1988), as follows: "Water vapor transmission through a 40-mil HDPE liner has been measured according to ASTM E96 to be 0.04 g/m^2/day (Matrecon Laboratory, 1983). This transmission rate is equivalent to 2.7×10^{-13} cm/sec."
4. Other assumptions utilized in the Wong equation are as follows:
   - Blanket permeability (cm/sec) .001
   - Liner permeability (cm/sec) 1×10^{-11}
   - Blanket porosity 0.3
   - Liner thickness (60 mil) 0.0049'
   - Base slopes Vary

TABLE NO. 2

Monthly Precipitation (Inches)
(1987)

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Rice Lake**	0.89	0.81	1.67	2.70	3.59	4.77	4.11	4.66	3.64	2.16	-	1.09	
Weyerhaeuser**	1.06	0.83	1.78	2.77	3.81	4.52	4.37	4.48	3.95	2.35	1.57	-	
Jump River 3E**	0.86	0.67	-	2.62	3.67	4.35	4.02	4.39	3.88	2.33	1.63	1.13	Total
Averages	0.94	0.77	1.73*	2.70	3.69	4.55	4.17	4.51	3.82	2.28	1.60*	1.11*	31.87

*Where no precipitation data is indicated, the monthly average is based on the remaining two quantities.

**Refer to attached state map for locations.

NOTE: 1. Quantities shown represent precipitation (inches), i.e., total recorded precipitation plus or minus departure from normal. Normal = 1951-1980. Source: Climatological Data - Wisconsin (1987), Volume 92.

2. For annual infiltration (inches) in Wong Equation calculations use 50% of total (average).
31.87 inches x 50 percent = 15.93 inches.

KMINE

TABLE NO. 3

Leachate Head (Feet)-Weighted Average

Weighted Average = Percent Area of Stockpile
Base X Predicted Leachate Head
at Given Percent Base Slope

Area Base (%)	Predicted Leachate Head (Feet)	
16	16.11*	2.58
13	6.40	0.83
10.1	4.43	0.45
5.9	4.43	0.26
15.9	10.02	1.59
13.9	6.42	0.89
25.2	9.08*	2.29
Weighted Average Leachate Head (Feet)		8.89

*Prorated for the actual life of the stockpile in these areas.

FOTH & VAN DYKE and ASSOCIATES / Waste Energy Division
LINER EFFICIENCY CALCULATIONS
ANNUAL ADDITIVE HEAD RECHARGE METHOD

FOR: kennecott

ANNUAL INFILTRATION (INCHES) 15.93

BLANKET PERMEABILITY (CM/SEC) .001
LINER PERMEABILITY (CM/SEC) 1E-11

BLANKET POROSITY .3
LINER THICKNESS (FEET) .0049
BASE SLOPE (FEET/FOOT) .0067

DRAINAGE DISTANCE (FEET) (VARIABLE)	EFFICIENCY (%)	LEACHATE HEAD (FEET)	T1 (YEARS)	T2 (YEARS)	COLL DIST (FEET)	T3 (YEARS)
160.0000	97.602	17.2517	6.92	%1160.33	160.0	6.92
170.0000	97.454	18.2522	7.36	%1168.34	170.0	7.36
180.0000	97.307	19.1215	7.79	%1174.95	180.0	7.79
190.0000	97.161	20.0851	8.22	%1181.93	190.0	8.22
200.0000	97.014	20.9743	8.66	%1188.09	200.0	8.66
210.0000	96.868	21.9111	9.09	%1194.29	210.0	9.09
220.0000	96.722	22.8142	9.52	%1200.03	220.0	9.52
230.0000	96.577	23.6388	9.95	%1205.07	230.0	9.95
240.0000	96.431	24.6439	10.39	%1210.99	240.0	10.39
250.0000	96.286	25.4834	10.82	%1215.75	250.0	10.82

NOTE:
1) T1 IS THE TIME FOR ONE COMPLETE COLLECTION CYCLE TO OCCUR.
1) T2 IS THE TIME FOR THE AVERAGE LEACHATE HEAD AT STEADY STATE CONDITIONS TO LEAK INTO THE LINER
3) THE COLLECTION DISTANCE NOTED IS THE MAXIMUM DISTANCE FROM THE LEACHATE COLLECTION LINE THAT THE STEADY STATE LEACHATE HEAD MAY BE EXPECTED TO FLOW INTO THE COLLECTION LINE BEFORE INFILTRATING THE LINER.
4) T3 IS THE TIME REQUIRED TO ACHIEVE STEADY STATE LEACHATE HEAD LEVELS.
5) Liner efficiencies calculated using a computer program based on an original program developed by the State of Wisconsin, Bureau of Solid Waste Management and presented at the Eight Annual Madison Waste Conference, September 18-19, 1985.

FOTH & VAN DYKE and ASSOCIATES / Waste Energy Division
LINER EFFICIENCY CALCULATIONS
ANNUAL ADDITIVE HEAD RECHARGE METHOD

FOR: kennecott

ANNUAL INFILTRATION (INCHES)	15.93
BLANKET PERMEABILITY (CM/SEC)	.001
LINER PERMEABILITY (CM/SEC)	1E-11
BLANKET POROSITY	.3
LINER THICKNESS (FEET)	.0049
BASE SLOPE (FEET/FOOT)	.0174

DRAINAGE DISTANCE (FEET) (VARIABLE)	EFFICIENCY (%)	LEACHATE HEAD (FEET)	T1 (YEARS)	T2 (YEARS)	COLL DIST (FEET)	T3 (YEARS)
80.0000	99.532	5.5235	1.33	998.73	80.0	1.33
90.0000	99.474	5.8896	1.50	%1007.84	90.0	1.50
100.0000	99.415	6.1826	1.67	%1014.74	100.0	1.67
110.0000	99.357	6.4222	1.83	%1020.14	110.0	1.83
120.0000	99.299	6.6220	2.00	%1024.48	120.0	2.00
130.0000	99.241	7.1242	2.17	%1034.87	130.0	2.17
140.0000	99.183	7.5546	2.33	%1043.20	140.0	2.33
150.0000	99.125	7.9277	2.50	%1050.04	150.0	2.50
160.0000	99.067	8.2542	2.67	%1055.77	160.0	2.67

NOTE:
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FOTH & VAN DYKE and ASSOCIATES / Waste Energy Division
LINER EFFICIENCY CALCULATIONS
ANNUAL ADDITIVE HEAD RECHARGE METHOD

FOR: kennecott

ANNUAL INFILTRATION (INCHES)	15.93
BLANKET PERMEABILITY (CM/SEC)	.001
LINER PERMEABILITY (CM/SEC)	1E-11
BLANKET POROSITY	.3
LINER THICKNESS (FEET)	.0049
BASE SLOPE (FEET/FOOT)	.0108

DRAINAGE DISTANCE (FEET) (VARIABLE)	EFFICIENCY (%)	LEACHATE HEAD (FEET)	T1 (YEARS)	T2 (YEARS)	COLL DIST (FEET)	T3 (YEARS)
100.0000	99.061	8.2875	2.68	%1056.25	100.0	2.68
110.0000	98.967	8.7296	2.95	%1063.63	110.0	2.95
120.0000	98.874	9.4019	3.22	%1074.16	120.0	3.22
130.0000	98.781	10.0188	3.49	%1083.19	130.0	3.49
140.0000	98.688	10.5475	3.76	%1090.49	140.0	3.76
150.0000	98.595	11.0575	4.03	%1097.20	150.0	4.03
160.0000	98.503	11.7184	4.30	%1105.44	160.0	4.30
170.0000	98.410	12.3015	4.56	%1112.34	170.0	4.56
180.0000	98.318	12.8198	4.83	%1118.20	180.0	4.83
190.0000	98.225	13.4023	5.10	%1124.51	190.0	5.10
200.0000	98.133	14.0212	5.37	%1130.92	200.0	5.37

NOTE:

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FOTH & VAN DYKE and ASSOCIATES / Waste Energy Division
LINER EFFICIENCY CALCULATIONS
ANNUAL ADDITIVE HEAD RECHARGE METHOD

FOR: kennecott

ANNUAL INFILTRATION (INCHES)	15.93
BLANKET PERMEABILITY (CM/SEC)	.001
LINER PERMEABILITY (CM/SEC)	1E-11
BLANKET POROSITY	.3
LINER THICKNESS (FEET)	.0049
BASE SLOPE (FEET/FOOT)	.04

DRAINAGE DISTANCE (FEET) (VARIABLE)	EFFICIENCY (%)	LEACHATE HEAD (FEET)	T1 (YEARS)	T2 (YEARS)	COLL DIST (FEET)	T3 (YEARS)
80.0000	99.796	4.4250	0.58	967.88	80.0	0.58
90.0000	99.771	4.4250	0.65	967.88	90.0	0.65
100.0000	99.745	4.4250	0.73	967.88	100.0	0.73
110.0000	99.720	4.4250	0.80	967.88	110.0	0.80
120.0000	99.694	4.4250	0.87	967.88	120.0	0.87
130.0000	99.669	4.4250	0.94	967.88	130.0	0.94
140.0000	99.643	4.4927	1.02	970.04	140.0	1.02
150.0000	99.618	4.7811	1.09	978.88	150.0	1.09
160.0000	99.593	5.0335	1.16	986.18	160.0	1.16

NOTE:

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1) T2 IS THE TIME FOR THE AVERAGE LEACHATE HEAD AT STEADY STATE CONDITIONS TO LEAK INTO THE LINER
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FOTH & VAN DYKE and ASSOCIATES / Waste Energy Division
LINER EFFICIENCY CALCULATIONS
ANNUAL ADDITIVE HEAD RECHARGE METHOD

FOR: kennecott

ANNUAL INFILTRATION (INCHES)	15.93
BLANKET PERMEABILITY (CM/SEC)	.001
LINER PERMEABILITY (CM/SEC)	1E-11
BLANKET POROSITY	.3
LINER THICKNESS (FEET)	.0049
BASE SLOPE (FEET/FOOT)	.0465

DRAINAGE DISTANCE (FEET) (VARIABLE)	EFFICIENCY (%)	LEACHATE HEAD (FEET)	T1 (YEARS)	T2 (YEARS)	COLL DIST (FEET)	T3 (YEARS)
100.0000	99.781	4.4250	0.62	968.15	100.0	0.62
110.0000	99.759	4.4250	0.69	968.15	110.0	0.69
120.0000	99.737	4.4250	0.75	968.15	120.0	0.75
130.0000	99.715	4.4250	0.81	968.15	130.0	0.81
140.0000	99.693	4.4250	0.87	968.15	140.0	0.87
150.0000	99.671	4.4250	0.94	968.15	150.0	0.94
160.0000	99.649	4.4250	1.00	968.15	160.0	1.00
170.0000	99.627	4.6784	1.06	976.06	170.0	1.06
180.0000	99.606	4.9084	1.12	982.88	180.0	1.12
190.0000	99.584	5.1142	1.19	988.72	190.0	1.19
200.0000	99.562	5.2995	1.25	993.78	200.0	1.25

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FOTH & VAN DYKE and ASSOCIATES / Waste Energy Division
LINER EFFICIENCY CALCULATIONS
ANNUAL ADDITIVE HEAD RECHARGE METHOD

FOR: kennecott

ANNUAL INFILTRATION (INCHES)	15.93
BLANKET PERMEABILITY (CM/SEC)	.001
LINER PERMEABILITY (CM/SEC)	1E-11
BLANKET POROSITY	.3
LINER THICKNESS (FEET)	.0049
BASE SLOPE (FEET/FOOT)	.024

DRAINAGE DISTANCE (FEET) (VARIABLE)	EFFICIENCY (%)	LEACHATE HEAD (FEET)	T1 (YEARS)	T2 (YEARS)	COLL DIST (FEET)	T3 (YEARS)
100.0000	99.576	5.1831	1.21	989.84	100.0	1.21
110.0000	99.533	5.5136	1.33	998.61	110.0	1.33
120.0000	99.491	5.7890	1.45	%1005.54	120.0	1.45
130.0000	99.449	6.0221	1.57	%1011.14	130.0	1.57
140.0000	99.407	6.2219	1.69	%1015.78	140.0	1.69
150.0000	99.364	6.3950	1.81	%1019.67	150.0	1.81
160.0000	99.322	6.5465	1.93	%1023.00	160.0	1.93
170.0000	99.280	6.7950	2.05	%1028.29	170.0	2.05
180.0000	99.238	7.1481	2.18	%1035.48	180.0	2.18
190.0000	99.196	7.4640	2.30	%1041.63	190.0	2.30
200.0000	99.154	7.7484	2.42	%1046.94	200.0	2.42

NOTE:

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LINER EFFICIENCY CALCULATIONS
ANNUAL ADDITIVE HEAD RECHARGE METHOD

FOR: kennecott

ANNUAL INFILTRATION (INCHES)	15.93
BLANKET PERMEABILITY (CM/SEC)	.001
LINER PERMEABILITY (CM/SEC)	1E-11
BLANKET POROSITY	.3
LINER THICKNESS (FEET)	.0049
BASE SLOPE (FEET/FOOT)	.0118

DRAINAGE DISTANCE (FEET) (VARIABLE)	EFFICIENCY (%)	LEACHATE HEAD (FEET)	T1 (YEARS)	T2 (YEARS)	COLL DIST (FEET)	T3 (YEARS)
390.0000	96.701	22.9385	9.58	%1200.86	390.0	9.58
392.0000	96.685	23.0346	9.63	%1201.45	392.0	9.63
394.0000	96.668	23.1298	9.68	%1202.04	394.0	9.68
396.0000	96.652	23.2240	9.73	%1202.62	396.0	9.73
398.0000	96.635	23.3172	9.78	%1203.19	398.0	9.78
400.0000	96.618	23.4095	9.83	%1203.75	400.0	9.83
402.0000	96.602	23.5009	9.88	%1204.30	402.0	9.88
404.0000	96.585	23.5914	9.93	%1204.85	404.0	9.93
406.0000	96.569	23.6810	9.98	%1205.39	406.0	9.98

NOTE:

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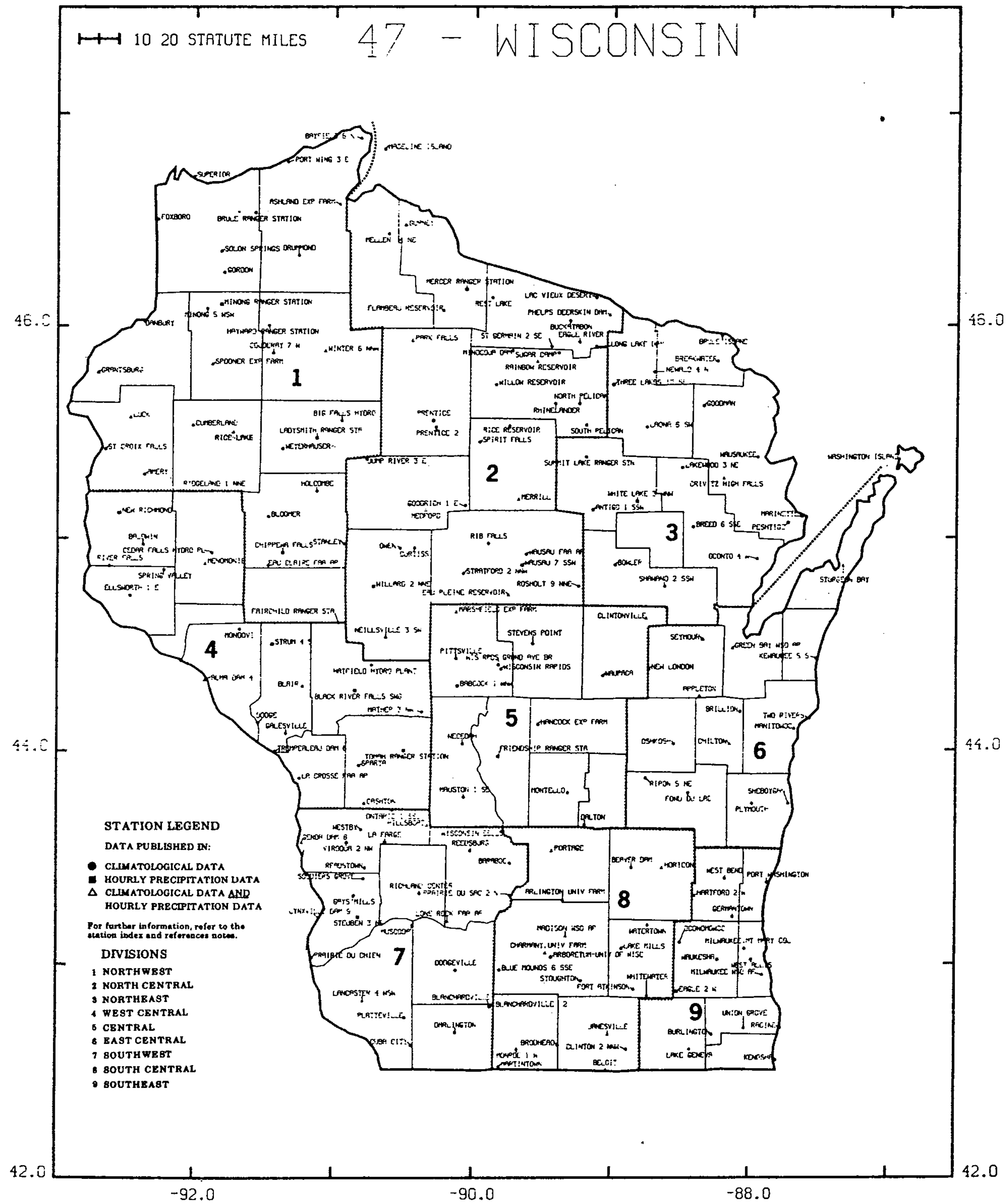
10 20 STATUTE MILES
47 - WISCONSIN
STATION LEGEND
DATA PUBLISHED IN:
● CLIMATOLOGICAL DATA
■ HOURLY PRECIPITATION DATA
△ CLIMATOLOGICAL DATA AND HOURLY PRECIPITATION DATA
For further information, refer to the station index and references notes.
DIVISIONS
1 NORTHWEST
2 NORTH CENTRAL
3 NORTHEAST
4 WEST CENTRAL
5 CENTRAL
6 EAST CENTRAL
7 SOUTHWEST
8 SOUTH CENTRAL
9 SOUTHEAST
46.0
44.0
42.0
-92.0
-90.0
-88.0

APPENDIX J

Supplier and Installation Specifications for HDPE Lining Material

TYPICAL SPECIFICATIONS FOR HDPE LINING MATERIAL SUPPLY AND INSTALLATION

1.0 GENERAL

1.1 This specification defines the requirements for High Density Polyethylene (HDPE) lining membranes, material, installation and quality control.

1.2 Lining material samples, manufacturer's certificates of compliance for material and specifications, and Installation Contractor's Quality Control/Quality Assurance Manuals for installation, shall be submitted with the lining Installation Contractor's bid for review. A copy of the lining manufacturer's Quality Control Manual shall be submitted for approval.

1.3 Any alternatives or exceptions to this specification shall be submitted in writing to the Owner's Representative and shall receive the Owner's written approval prior to implementation in the work.

1.4 Within 15 calendar days following award of contract, the Contractor shall submit shop drawings showing as a minimum:

A. Layout of liner system.
B. Details of joining and seaming liner system.
C. Details of liner anchorage system.
D. Details of connecting liner to concrete.
E. Details of liner penetration systems.

2.0 LINING MATERIAL

2.1 The membrane liner shall be a high quality formulation, containing approximately 97% polymer and 3% carbon black with anti-oxidants and heat stabilizers. It shall be warranted to resist ultra violet rays for a period of 10 years.

2.2 The membrane liner shall consist of polyethylene resin of new, first-quality product, designed and manufactured specifically for the purpose of liquid containment in hydraulic structures.

2.3 The liner material shall be so produced as to be free of holes, blisters, undispersed raw material, or any sign of contamination by foreign matter. The Installation Contractor shall be responsible for visually inspecting the sheet surface during unrolling in accordance with approved Quality Assurance procedures. Any faulty areas or defects shall be marked. Any such defect shall be repaired using extrusion or fusion welding techniques approved by the Owner's Representative.

2.4 The material provided as high density polyethylene (HDPE), 60 mil liner shall meet or exceed the minimum requirements as stated in the National Sanitation Foundation (NSF) Standard Number 54 as well as the manufacturers published minimum specifications. The minimum standards as listed in Table 2.4 shall be met.

3.0 QUALITY ASSURANCE - MATERIALS

3.1 Prior to delivery of the HDPE material to the job site, the fabricator or manufacturer shall submit certificates of compliance with the HDPE material properties requirements of this specification, for compliance and acceptance, to the Owner's Representative.

3.2 Acceptable Certification of compliance will require two levels of documentation consisting of the following:

3.2.1 Raw Material Certification

These documents will state the origin, identification (brand name), and production date(s) of the resin as well as quality control certificates noting density and melt index results. The liner manufacturer shall include reports of tests, conducted by them, to verify quality of the resin.

3.2.2 Geomembrane (HDPE Liner) Manufacturers Certification

Documents are to include properties specifications, description of base polymers, sampling procedures and results of testing done during fabrication. A guarantee that the HDPE sheet meets the property values as listed in paragraph 2.4 is required.

TABLE 2.4

PROPERTY	TEST METHOD	VALUE	UNITS
a) Density (min)	ASTM D-1505	0.935	gm/ccm
b) Thickness	ASTM D-1593	60 mils (± 10%)	
c) Strength & Properties (min)	ASTM D-638 Type IV		
Tensile			
@ Break		180	lb/in of width
@ Yield		120	
Elongation			
@ Break		500	%
@ Yield		10	%
Modulus of Elasticity	ASTM D-882	80,000	lb/sq.in.
d) Tear Resistance Initiation (min)	ASTM D-1004 Die C	45	lb.
e) Puncture Resistance	FTMS 101B	175	lb.
f) Coefficient of Linear Expansion	ASTM D-696	0.00012	per deg.C
g) Hydrostatic Resistance	ASTM D-751 Method A Procedure 1	315	psi
h) Water Absorption	ASTM D-570	0.1	max % weight change
i) Melt Index (max)	ASTM D-1238	0.3	Grams/10 min.
j) Environmental Stress Crack	ASTM D-1693	1500	hours
k) Carbon Black Content	ASTM D-1603	2.0% (min.)	
l) Bonded Seam Strength		Equal or greater than base membrane.	

4.0 STORAGE AND HANDLING OF MATERIALS

4.1 All HDPE rolls shall be stored and handled per the manufacturers specifications and quality assurance procedures in such a manner as to prevent damage to any part of the product. Field stored rolls will be placed on supports to protect material from sharp rocks, sticks and debris.

4.2 The Installation Contractor shall be responsible for inspection of the sheet rolls at the jobsite. Should rolls show damage from transit, they will be identified by the Contractor for acceptable repair or return to supplier.

During unrolling of the lining material, the Installation Contractor will carry out visual inspection of the sheet surface. Any faulty areas shall be marked and repaired in accordance with approved quality control and assurance procedures by the Installation Contractor to the satisfaction of the Owner's Representative.

5.0 INSTALLATION

5.1 Subgrade preparation by the excavation Contractor for the Type II Stockpile, fuel storage area, crushed ore stockpile area, and ponds by the Contractor must insure that the surfaces to be lined are smooth and free of rocks, stones, sticks, sharp objects and debris. The Installation Contractor shall certify that the surface on which the membrane is to be installed is acceptable before commencing work. For the duration of the HDPE liner installation it shall be the Installation Contractors responsibility to maintain the surface at design conditions. Should the surface become damaged by storm runoff or, conversely dried to the point such that cracking may develop, the installation shall cease until such a time that the subgrade is modified in accordance with the specifications and deemed acceptable by the Owners Representative.

5.2 Installation shall be performed under the direction of a Field Engineer who has installed a minimum of 2,500,000 square feet of HDPE flexible lining material. The Field Engineer shall be provided by the Installation Contractor, and shall be in charge of the installation.

5.3 Handling of the geomembrane panels during placement should be done without damaging, scratching or crimping the geomembrane. All panels should be placed with a minimum amount of wrinkles. Panels should be properly weighed or anchored using sandbags or other approved methods to avoid uplift or damage due to the wind. Geomembrane panels should not be placed in excessive winds. All personnel working on the geomembrane shall not smoke, wear damaging shoes or engage in other behavior which could damage the geomembrane.

5.4 To compensate for wrinkles, shrinkage/expansion, and material overlap, Contractor must indicate at time of tendering a percentage allowance computed in his material take-off.

5.5 **Field Seams**

5.5.1 Individual panels of HDPE liner material shall be laid out and overlapped prior to welding. Seams shall generally be oriented along, not across, the line of prevailing slope. Extreme care shall be taken by the installer in the preparation of the areas to be welded. The area to be welded shall be cleaned and prepared according to the procedures outlined by the material manufacturer. All sheeting shall be welded together by an extrusion or fusion process or an approved equivalent method. Contractor shall define and detail method used in fusion of panels proposed for liner installation. A sample weld shall be made by each welder prior to commencement of field welding each day. The weld samples shall be tested in shear and peel to meet specification requirements by the Installation Contractor. Two samples minimum shall be taken during each shift.

5.5.2 The fusion welding equipment used shall be capable of continuously monitoring and controlling the temperatures in the zone of contact where the machine is actually fusing the lining material, to ensure changes in environmental conditions will not affect the integrity of the weld. For extrusion welding, the extruder shall be equipped with a temperature gauge at the barrel and nozzle.

5.5.3 No "fish mouths" shall be allowed within the seam area. Where "fish mouths" occur, the material shall be cut, overlapped, and an overlap extrusion weld shall be applied. All welds on completion of the work shall be tightly bonded. Any membrane area showing damage due to scuffing, puncture, or distress caused by the Installation Contractor, shall be replaced or repaired with an additional piece of HDPE membrane at the expense of the Installation Contractor.

5.5.4 Fusion of panels and repairs will only be permitted under weather conditions allowing such work, and within the warranty limits imposed by the liner manufacturer.

5.6 All sheets shall be laid in place and overlapped the proper amount, as recommended by the manufacturer, for lap seams as they are unrolled. During unrolling of the HDPE sheets, the Installation Contractor shall carry out visual inspection of the sheet surface. Sheets shall be placed in the correct locations with a minimum of sliding over the subgrade. Any faulty areas shall be marked and repaired by Installation Contractor. Adequate temporary anchorage, shall be immediately placed on the edges of any sheets that are unrolled and subject to displacement by wind. The Installation Contractor shall be responsible for repairing or replacing any HDPE liner that is damaged by wind prior to completion of the installation. The liner shall not be seamed when, in the judgement of the Installation Contractor or Engineer, weather conditions will preclude seaming within the manufacturer's warranty conditions.

5.7 The anchor trenches shall be excavated a minimum of 3 feet from the dike edge toward the dike centerline. The trench installation will be the responsibility of the Installation Contractor. The length of the open trench should not exceed the amount of liner to be placed in 2 days unless approval in writing has been obtained from the Owner's Representative. The anchor trench shall be only partially backfilled after geomembrane placement. Compaction of the backfill shall begin after new HDPE and/or geomembrane has been welded to the existing liner and the geomembrane has experienced at a minimum 3 expansion/contraction cycles due to the temperature changes.

Final backfill shall be placed in thin lifts not to exceed 6 inches in loose thickness and shall be compacted with hand operated compaction equipment to a minimum of 90% of the maximum dry density modified Proctor test (ASTM D 1557). The total weight of compaction equipment should not exceed 300 pounds. The backfill shall be a fine sand (SP) free of any debris, sticks, gravel or material greater than 3.0 inches in diameter. The Owner's Representative shall be informed prior to the final anchor trench backfill and compaction.

6.0 FIELD SEAM TESTING/QUALITY CONTROL

6.1 The installer shall employ on-site physical non-destructive testing on all welds to ensure watertight homogeneous seams on a continuous basis as installation proceeds. Each seam shall, under the observation of the Owner's Representative, be tested by vacuum methods with a minimum vacuum pressure of 5 psig applied for not less than 30 seconds, or by pressure testing at 30 psig with a maximum allowable drop of no more than 4 psig in 5 minutes, or by an approved equivalent method. Visual inspection alone is unacceptable. Any non-destructive tests that fail will be repaired.

6.2 The Owner's Representative and the Installation Contractors Quality-Control Technician or Field Engineer shall inspect each seam. Any area showing a defect shall be marked and repaired in accordance with these specifications and approved HDPE repair procedures and retested.

6.3 A test weld three (3) feet long from each welding machine shall be run each day prior to liner welding. The test weld shall be marked with date, ambient temperature, and welding machine number. Samples of the weld shall be cut from the test weld and tested in shear and peel. Welds shall have seam strength of 90 percent of the tensile strength of the parent material. Peel tests shall have a film tearing bond failure. Seams shall be stronger than the material. The weld sample shall be kept for subsequent testing on laboratory tensiometer equipment in accordance with the applicable ASTM standards. Random weld samples will be removed from the installed welded sheeting at a frequency of 1 test per 500 lineal feet of seam and shall be tested in a laboratory in accordance with the aforementioned procedures.

6.4 For field seams that fail non-destructive or destructive tests, the seams may either be reconstructed between the failed and any previously passed seam location or the Contractor may go on either side of the failed seam, take additional samples for testing, and if these pass, reconstruct the seam between the two locations. In all cases, the repaired seams shall be bounded on either side by passed test locations. All repaired seams must be retested as per Section 6.1.

7.0 QUALITY ASSURANCE REPORTS

The Owner's Representative shall submit reports of observations and tests to the Owner. The reports shall be submitted to the Owner in a timely fashion.

A copy of all test results will be maintained at the construction site

Test reports shall include, but not necessarily be limited to:

- o Thickness of geomembrane - test each roll
- o Density of geomembrane - test each roll
- o Melt Flow Index
- o Tensile Strength - yield and break strength
- o Percentage Elongation - percentage @ yield and break
- o Peel Testing of Welds
- o Shear Testing of Welds

The results shall include the following:

A. Date issued
B. Project title and number
C. Date of testing and or/sampling.
D. Type of test.
E. Location of test.
F. Observations regarding compliance or noncompliance with plans and specifications.

Upon completion of construction, the Owner's Representative shall submit a final quality assurance report verifying that the project was completed in accordance with plans and specifications and presenting all tests, as-built plans and other supporting data.

APPENDIX K

Design/Operations Manual for a One-Time
Demolition Waste Disposal Facility
for the Flambeau Project

DESIGN/OPERATIONS MANUAL
FOR A ONE-TIME DEMOLITION WASTE DISPOSAL FACILITY
FOR THE
FLAMBEAU PROJECT

WISCONSIN
GERALD W.
SEVICK
E-15308
Green Bay,
Wis.
PROFESSIONAL ENGINEER

Gerald W. Sevick
12-29-89

Prepared for:

FLAMBEAU MINING COMPANY

Prepared by:

FOTH & VAN DYKE and Associates Inc.
2737 S. Ridge Road
P. O. Box 19012
Green Bay, Wisconsin 54307-9012

DECEMBER 1989

Foth & Van Dyke
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Green Bay, Wisconsin 54307-9012
414/497-2500
FAX: 414/497-8516

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1.0 INTRODUCTION

Flambeau Mining Company (Flambeau), a wholly-owned subsidiary of Kennecott Corporation is proposing to develop a copper mine near Ladysmith, Wisconsin. As part of the project numerous federal, state, and local environmental, construction, building, and safety permits and approvals will need to be obtained. One step in the permitting process is the issuance of a written plan approval by the Wisconsin Department of Natural Resources (WDNR) for a one-time disposal site under NR 502.12 for demolition and construction materials generated during the reclamation of the mining site. Given the fact that less than 10,000 cubic yards of such material will be placed in the proposed site and the fact that the life of the site will be six months or less, the provisions of NR 502.12 apply to the approval, construction, operation and closure of the proposed site. This report and accompanying engineering drawings provide the general facility, geological, hydrogeological, topographic, engineering, and other information needed by the WDNR for their review and approval of the facility. With this application, Flambeau is requesting that the WDNR approve its proposed one-time demolition waste disposal facility.

Some of the information required in this application has been previously or simultaneously submitted to the WDNR in the project's Environmental Impact Report or the Mining Permit Application. In an effort to avoid duplication, such information, when appropriate, is included in this application by reference. The references are specific to section and drawing numbers to aid the reviewers in completing their work. By a November 17, 1989 letter (Appendix I), WDNR concurred with this approach.

The proposed disposal facility is to be located in the northeastern settling pond within the proposed mining site area. Figure No. 1-2 of the Mining Permit Application shows the location of the mining site, while Figure No. 4-1 of that document shows the location of the northeastern settling pond in relation to other project facilities.

This report is divided into five parts. Section 1.0 discusses the purpose and scope of the project. Section 2.0 includes a description of the site, a discussion of alternatives, and identifies the project owner and contact. Section 3.0 describes the physical characteristics of the site, including site topography, hydrology, geology and hydrogeology. The subsurface investigation programs are also discussed with pertinent data provided or referenced. Section 4.0 discusses design criteria, waste volumes, site closure and monitoring. Section 5.0 presents report conclusions regarding the suitability of the proposed site for its intended purpose.

2.0 GENERAL FACILITY INFORMATION

2.1 Project Title, Owner and Contact

Project Title:	Flambeau Project One Time Demolition Waste Disposal Facility
Primary Contact:	Lawrence E. Mercando, Project Manager Flambeau Mining Company 10 East South Temple P.O. Box 11248 Salt Lake City, UT 84147 (801) 322-8460
Engineering Consultant:	Foth & Van Dyke and Associates Inc. Geosciences and Environmental Management Group 2737 S. Ridge Road P.O. Box 19012 Green Bay, WI 54307-9012 (414) 497-2500
Facility Owner and Operator:	Flambeau Mining Company

2.2 Site Description, Property Ownership, and Miscellaneous Information

The proposed one-time disposal facility is located in the NE 1/4 of Section 9, T34N, R6W, Town of Grant, Rusk County, Wisconsin. The proposed site is located just south of the City of Ladysmith. The property the site is located on is owned by Flambeau Mining Company. Section 4.6.3 and Figure No. 2-4 of the December 1989 Mining Permit Application for the Flambeau Project (Mining Permit Application) can be referred to for property ownership information.

The proposed landfill area will occupy approximately 0.9 acres and have a site life of six months or less. The proposed site has a design capacity of 7,500 cubic yards.

The site will be opened, filled, and closed as part of reclamation activities associated with the Flambeau project. Waste types include concrete from retaining walls, footings, and slabs; bituminous surfaces from parking lots and access roads; riprap; culverts; the site septic tank or holding tank; and miscellaneous material from the demolition of on-site buildings.

2.3 Alternatives

Alternatives to the proposed facility include the salvaging of the material requiring disposal or disposal at another licensed facility. Each alternative is discussed below.

As part of the mining site reclamation plan, a significant amount of recycling or reuse of on-site machinery or building equipment will take place. Such efforts consist of the salvaging of buildings, railroad rails and ties, equipment, tanks, and the pit itself through backfilling efforts. The materials to be placed in the proposed facility consist of those for which salvaging or recycling are not economical or practicable.

There are currently two licensed landfills located within a 55-mile radius of the proposed site. One, owned by Rands Disposal, is a 50,000 cubic yard demolition landfill located approximately 1 1/2 miles southeast of Ladysmith. This facility has an expected site life of five or six years. Therefore, this landfill will be closed prior to the time the disposal of demolition material from the proposed mining project will be required. The second site is the Lake Area Disposal Sanitary Landfill, which is a 978,000 cubic yard municipal solid waste landfill located in Washburn County approximately 55 miles to the northwest of the proposed mining site. This facility has a site life of over 14 years beginning from the fall of 1988.

The unavailability of demolition landfill space in the immediate area and the extremely long haul distance to the nearest municipal landfill indicates that viable disposal alternatives do not exist. Therefore, a definite need to develop the proposed facility exists.

2.4 Initial Site Inspection

As per NR 502.12 (3), an initial site inspection is to be conducted by the WDNR prior to submittal of the project report. As per a letter dated November 17, 1989 from the WDNR to Foth & Van Dyke (Appendix I), the NR 502.12 (3) requirement has been fulfilled through the numerous on-site inspections conducted by WDNR personnel over the course of the development of the mining project.

3.0 SITE GEOTECHNICAL INFORMATION

3.1 Overview of Site Geology and Hydrogeology

The proposed disposal site primarily overlies an area characterized by pitted glacial-fluvial sediment. This area, shown as Area C on Figure No. 3-1 of this report, is generally at an elevation of 1,120 to 1,130 feet. As shown in cross-section on Figure No. 3.5-5 of the April 1989 report titled, Environmental Impact Report for the Kennecott Flambeau Project (EIR), the site area is underlain by coarse-grained, glacial-fluvial sediment. The glacial-fluvial sediment is irregularly bedded and stratified, very poorly sorted, and typically contains cobbles and some large boulders. The coarse texture and poor sorting probably indicates the sediment was deposited by melt water near the margin of the ice sheet. After recession of the ice margin, the Flambeau River cut into the glacial-fluvial sediment.

Underlying a portion of the eastern end of the site, and to the east of the site, lies Area B, a dissected terrace surface which occurs typically at an elevation of 1,140 feet. The surface is an erosional feature cut into silty sand till, with some deposition of glacial-fluvial sediment at the surface. The surface may have been formed by glacial meltwater which eroded a broad channel into the till surface. Later, glacial-fluvial sediment was deposited as meltwater flow subsided.

Between the site and the Flambeau River is Area D, a low, relatively flat area at a general elevation of 1,100 to 1,110 feet. Area D is underlain by poorly sorted glacial-fluvial sediment that is covered by recent, fine-grained alluvial sediment at the surface. The surface was formed by the meandering Flambeau River in recent time.

Beneath all these features lies a five to ten-foot layer of Cambrian sandstone, typically medium grained and very poorly cemented. Beneath this unit are Precambrian metavolcanic rocks. These are schistose rocks occurring in layers that strike N45°E and dip 70°NW. Beneath the site, they are generally relatively soft and highly altered, with poorly developed fracturing.

Depth to groundwater beneath the base grade of the one time disposal site under post reclamation equilibrium conditions is expected to stabilize in the range of 15 to 22 feet. At that time, the groundwater flow direction will be westward, toward the Flambeau River. Previous to this, as the water table recovers from the mining cone of depression, the flow direction will have a southerly component, toward the center of the backfilled pit.

As described in the EIR, flow rates in the glacial-fluvial sediment will probably be on the order of 0.60 feet per day. As shown in the EIR, this is based on a logarithmic mean permeability of 2.1×10^{-3} cm/sec, a present-day hydraulic gradient of 0.02 ft/ft (similar to what is predicted under post reclamation equilibrium conditions), and an effective porosity of 20 percent.

3.2 Site Topography and Hydrology

The proposed one-time disposal area lies on the west side of the proposed mining site. Figure Nos. 2-2 and 4-1 of the Mining Permit Application show site topography at a scale of one inch equals 600 and 400 feet, respectively. The existing ground tends to slope to the west toward the Flambeau River. Drainage from the proposed disposal area will tie into a swale that flows to the west. Mining site topography (one-inch equal to 200 feet) and settling pond location are also shown on Figure No. 4-7 Site Grading and Drainage Plan - South, and Figure

No. 4-14 Site Grading and Drainage Plan - North, of the Mining Permit Application drawings. Site specific topography at a scale of one inch equals 100 feet is shown on Figure No. 4-1 of this report.

Figure Nos. 4-1, 4-7 and 4-14 of the Mining Permit Application show drainage patterns for the mining site in addition to adjacent roads, homes, and water courses. Figure No. 3.6-2 of the EIR shows water supply wells in the vicinity of the mining site. Figure No. 4 of Appendix 3.8-C of the EIR shows wetlands in the vicinity of the mining site. Site specific hydrology is discussed in detail in Sections 3.7.2 and 3.7.3 of the EIR.

3.3 Subsurface Investigation Programs

An extensive geotechnical investigation of the area has been completed for the Flambeau Project mining site. The investigations are presented in Section 3.5.1 of the EIR prepared by Foth & Van Dyke and Associates Inc. Soil borings used to describe the geology of the proposed site are MW-1004, ST-9-3, ST-9-20, ST-9-65, ST-9-66, and ST-9-67. Grain size reports and soil boring logs can be found in Appendices 3.5-B and 3.5-D of the EIR.

Numerous groundwater monitoring wells were installed as part of the EIR to define the water table surface and hydraulic gradients for the mining site. Well construction diagrams and well development forms can be found in Appendix 3.5-D of the EIR. The locations of the soil borings and monitoring wells are shown on Figure 3.5-2 of the EIR.

3.4 Site Geology and Hydrogeology

A detailed report of site geology is presented in Section 3.5 of the EIR. Ten geologic cross sections are presented in the EIR to illustrate site geology. Of these, four pass through or are in the vicinity of the proposed demolition site area. These are geologic cross sections B-B', C-C', E-E' and G-G'. They are shown on Figure Nos. 3.5-4, 3.5-5, 3.5-7 and 3.5-9 of the EIR. The geologic cross section location map is shown on Figure No. 3.5-2 of the EIR.

On April 6, 1988 and September 6, 1988, Foth & Van Dyke measured the groundwater elevations in the monitoring wells and piezometers on the mining site. These elevations were used to construct both high and low groundwater table contour maps. Figure Nos. 3.6-4 and 3.6-5 of the EIR depict these groundwater contour maps.

3.5 Soils of the Project Area

For a detailed description and interpretation of the soil conservation service soil map refer to Section 3.5.3.2 of the EIR. Figure No. 2 of Appendix 3.8-C of the EIR shows the soil boundaries and unit names. A discussion of surficial geology and presentation of site grain size analyses is presented in Section 3.5.3.3 of the EIR.

3.6 Groundwater Quality

The groundwater quality of the proposed area is discussed in detail in Sections 3.6.2.6 and 3.6.4 of the EIR. Please refer to this section for information pertaining to this topic.

4.0 ENGINEERING DESIGN

4.1 Location and Performance Criteria

NR 502.12(2) requires one-time disposal sites to meet the location and performance criteria specified in NR 502.04 unless an exemption is provided. As discussed below, the proposed demolition site meets all required location and performance criteria.

NR 502.04(2) - The proposed facility is <u>not</u> located within:

(a) 1000 feet of a navigable lake, pond, or flowage.

(b) 300 feet of a navigable river or stream.

(c) A flood plain.

(d) 1000 feet of the nearest edge of right-of-way of a state trunk highway, interstate or federal aid primary highway or the boundary of a public park.

(e) (Does not apply since the facility is not to be used for handling putresible waste).

(f) 1200 feet of a public or private water supply well. (See Figure No. 3-1).

NR 502.04(3) - There is <u>not</u> a reasonable probability that the facility will cause:

(a) A significant adverse impact on wetlands.

(b) A significant adverse impact on critical habitat areas.

(c) A detrimental effect on surface waters.

(d) A detrimental effect on groundwater quality or will cause or exacerbate an attainment or exceedance of any preventative action limit or enforcement standard at a point of standards application as defined in s. NR 140.

(e) The migration and concentration of explosive gases in any facility structures or in the soils or air at or beyond the facility property boundary in excess of 25 percent of the lower explosive limit for such gases.

(f) The emission of hazardous air contaminants exceeding the limitations for those substances contained in s. NR 445.03.

4.2 Design Criteria

The design of the proposed one-time disposal facility was based on the criteria specified in NR 502.12(5)(a), (b), (d), and (e); and NR 502.13 (4) (f), (g), and (h). The site was located to best utilize the proposed mining plan's construction facilities. This will allow a minimum of berm construction while allowing final grades to be sloped to the west to mirror as close as practicable the existing topography. A separation distance of approximately 300 feet exists between the demolition site and the mine pit. Due to its location on the mine site, the facility will be adequately screened from residents within one-quarter mile.

4.3 Waste Volumes, Site Operation, and Site Life

The proposed one-time disposal facility will receive demolition waste from the completion of reclamation of the mining facilities. Wastes to be placed in the site include approximately 2,500 cubic yards of concrete; 570 cubic yards of bituminous surface; 500 cubic yards of riprap; 100 cubic yards of culverts and septic tanks; and miscellaneous material from the demolition of on-site buildings or facilities. The total volume equals approximately 3,670 cubic yards. The 3,670 cubic yard figure represents the best estimate of the volume of these material prior to their removal as part of the site reclamation project. Given the fact that the actual volume of material requiring disposal in the site will not be known until reclamation takes place, and the fact that the in-place volume of material in the demolition site will be greater than their in-place volume prior to removal due to swelling, a design volume for the site of 7,500 cubic yards has been selected. If actual in-place volume is less than the 7,500 cubic yard figure used for site design, final grades will be achieved using on-site general earth fill.

The site will be operated as an area fill. Site life will be six months or less. Given the short site life and innocuous nature of the material to be placed in the facility, daily or intermediate covering is not necessary.

A detailed schedule of the mining project reclamation activities is shown in Figure No. 5-1 of the Mining Permit Application. The schedule shows that some of the material to be placed in the disposal site will potentially be generated prior to the time that the settling ponds will be taken out of service. In this event, such material will be temporarily placed in the eastern explosive magazine area.

The explosive magazines will be removed prior to the generation of demolition waste and therefore, the areas will be available for such use. The explosive magazine area will be graded to drain to the settling ponds, if used as described. Once the demolition area has been prepared, any material placed in the explosive magazine area will be moved into the permanent disposal site.

Material to be disposed of in the proposed site will be delivered using on-site equipment and spread, and compacted by at least three passes with an on-site tracked dozer. Soil to be used for final cover will be transported using dump trucks or scrapers.

4.4 Site Access

Proposed access to the facility will be along the proposed access roads for the mining plan. The mining plan includes controlled site access through the use of fencing. Upon closure of the facility, the proposed access roads will be reclaimed as per the reclamation plan for the Flambeau Project.

4.5 Base Grades

The proposed facility will use the existing berms from the eastern settling pond of the proposed mining plan. The bottom of the settling pond will be backfilled approximately seven feet to bring the base elevation for the disposal site to 1122.0. Filling will be accomplished in one-foot compacted lifts. Compaction will be accomplished by three passes of a tracked dozer over the placed soil. The backfill will provide a projected 17-foot separation above the projected post reclamation groundwater table. This separation distance is greater than the ten-foot separation distance specified in NR 502.12(5)(d) of the Wisconsin Administrative Code. Figure Nos. 4-1 and 4-2 of this report illustrate design base grades for the proposed facility.

4.6 Final Grades

The final cover system will consist of a two-foot-thick layer of compacted on-site SM or SM-ML material overlain with six inches of topsoil. Final grades will be sloped to the west at 3.6 percent to match the drainage pattern of the reclaimed mine site as shown on Figure No. 5-3 of the revised Mining Permit Application. Final grades are illustrated on Figure Nos. 4-1 and 4-2 of this report.

4.7 Surface Water Drainage

Surface water will be diverted around the fill area via perimeter drainage swales to limit the potential for erosion and sedimentation. Details of the perimeter drainage system are shown on Figure Nos. 4-1 and 4-2 of this report.

4.8 Site Closure

Portions of the site will be brought to final grade as soon as practical. As these portions reach final grade, final cover shall be applied to limit surface water infiltration. Final cover will be placed within six months after disposal begins.

The final cover system will consist of two feet of compacted on-site SM or SM-ML soils and six inches of topsoil. The two-foot soil layer will be placed in two one-foot lifts, each compacted through a minimum of three passes with a tracked dozer. Following topsoil placement, the surface will be seeded, fertilized, and mulched in accordance with the mining site's revegetation plan. Following closure, the facility will be inspected and maintained in accordance with the mining site's long-term care and maintenance plan as described in Section 10.0 of the Mining Permit Application.

4.9 Environmental Monitoring

Demolition wastes are not associated with the creation of landfill gas. Therefore, gas monitoring is not proposed for this facility.

An extensive groundwater monitoring program for the mining site has been proposed as part of the Mining Permit Application for the project. This plan is detailed in Sections 7.0 and 10.0 of that document. Given the nature and volume of materials to be placed in the proposed site and the fact that an overall site monitoring plan will be implemented, a specific groundwater monitoring plan for the one-time demolition waste site is not appropriate.

5.0 CONCLUSIONS

The information presented in this report shows that the proposed facility meets or exceeds the criteria specified in NR 502.12 for the construction, operation, and closure of a one-time demolition waste disposal facility.

APPENDIX I

Correspondence From WDNR

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Besadny
Secretary

BOX 7921
MADISON, WISCONSIN 53707

November 17, 1989

File Ref: 2720

Mr. Jerry Sevick, P.E., Manager
Geosciences and Environmental Management Group
Foth & Van Dyke
P. O. Box 19012
Green Bay, WI 54307-9012

Dear Mr. Sevick:

This letter is in response to recent conversations we have had concerning construction of a demolition waste disposal site for the proposed Flambeau Mining Company project near Ladysmith. You have inquired as to the applicability of certain requirements of Chapter NR 502, Wis. Adm. Code as they relate to the approval of such a facility. Specifically, you have asked whether an initial inspection pursuant to s. NR 502.12(3) is necessary and whether the applicant must generate additional geotechnical and hydrogeologic information in accordance with ss. NR 502.13(4)(b) and (c).

Various Department staff have inspected the entire area to be disturbed by the proposed mining project, including the area proposed for the demolition site, and are familiar with the site. Therefore, it is not necessary to conduct another site inspection before submittal of the report required under s. NR 502.12(4).

Sections NR 502.13(4)(b) and (c) require submittal of geotechnical and hydrogeologic information relative to the proposed demolition waste disposal site. A discussion of the site characteristics should be included in the report, but you may rely on data gathered in support of and submitted in the Environmental Impact Report. There does not appear to be a need for additional data at this time.

If you have any questions regarding this matter please contact me.

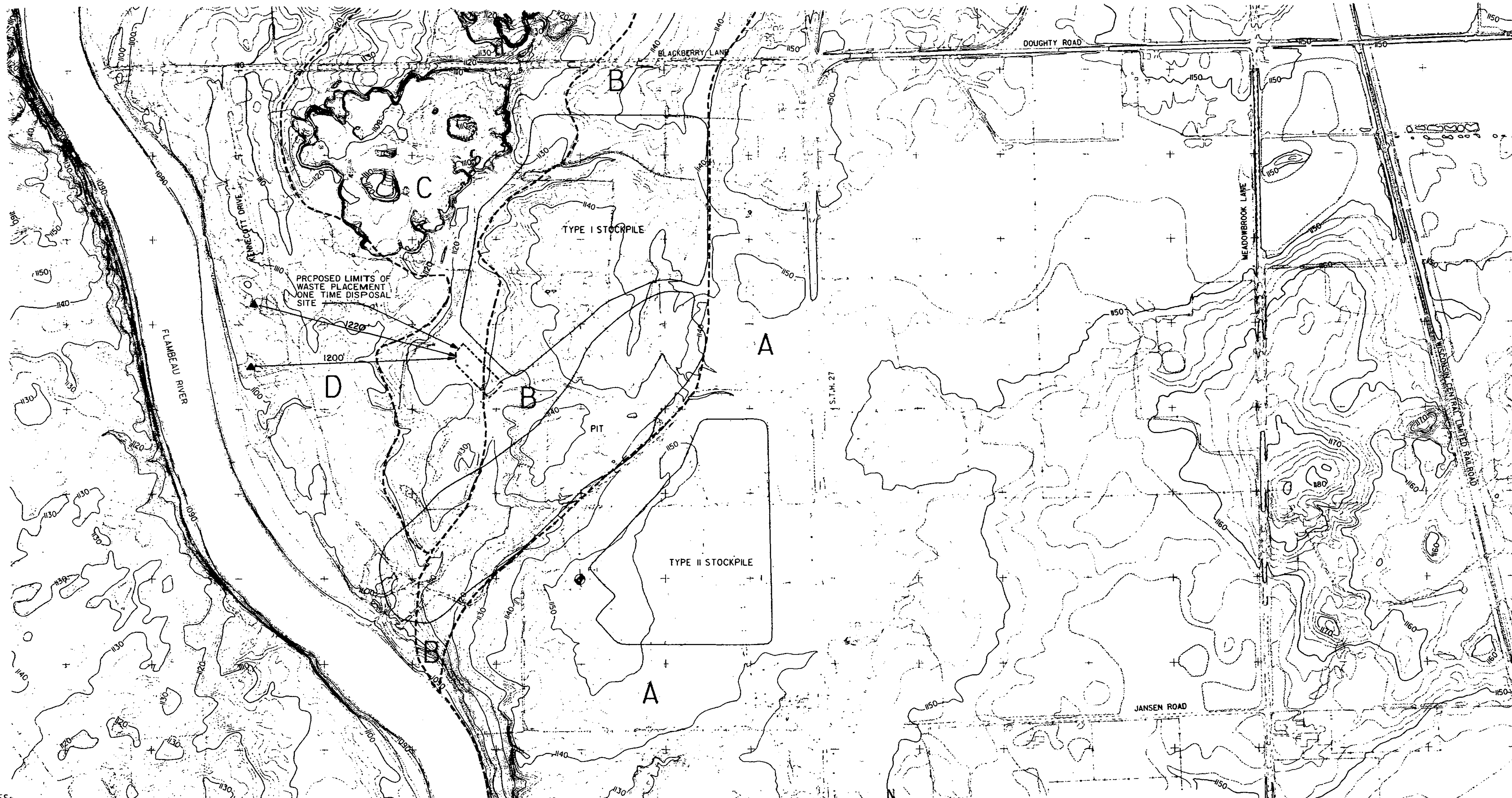
Sincerely,

Lawrence J Lynch

Lawrence J. Lynch, Environmental Specialist
Office of Mine Reclamation
Bureau of Solid & Hazardous Waste Management

cc: Bob Ramharter - EA/6
Larry Mercando - Kennecott
Hank Handzel - DeWitt, Porter et. al.
Bill Thiel - Jordan, Herrell and Thiel
Tom Evans - WG&NHS
Kathy Falk - DOJ
Dennis Leong - DOD

FIGURES FOR SECTIONS 3.0 AND 4.0



NOTES:

1. SITE LOCATION: SECTIONS 9, 10, 15 & 16, T34N, R6W, RUSK COUNTY, WISCONSIN.
2. TOPOGRAPHIC BASE MAP PREPARED FROM AERIAL SURVEY BY SURDEX CORPORATION, CHESTERFIELD, MISSOURI. DATE OF PHOTOGRAPHY - APRIL 24, 1970. ROADS, TREES AND BUILDINGS WERE UPDATED AS PER AERIAL PHOTOGRAPH TAKEN BY MARKHURD CORPORATON, MINNEAPOLIS, MINNESOTA. DATE OF PHOTOGRAPHY - SEPTEMBER 14, 1987.
3. ELEVATIONS BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS TWO FEET.
4. HORIZONTAL DATUM BASED ON PROJECT SITE GRID SYSTEM. SITE GRID COORDINATES CORRELATION TO STATE PLANE COORDINATES DERIVED AS FOLLOWS:

SITE GRID COORDINATES CONTROL MONUMENT F-1	STATE PLANE COORDINATES
40000 N =	587, 357. 8087 N
40000 E =	1, 713, 516. 1229 E

THE ANGULAR ROTATION FROM STATE PLANE BEARINGS TO SITE GRID BEARINGS IS 359°-13'-23" RIGHT WITH CONTROL POINT F-1 AS THE BASE POINT.

LEGEND

—1100—	EXISTING CONTOUR
	EXISTING PAVED ROADWAY
	EXISTING TRAIL/GRAVEL SURFACE
	TREES AND/OR BRUSH
	FENCE
F-1	CONTROL MONUMENT
▲	PRIVATE WELL LOCATION
- - - -	APPROXIMATE BOUNDARY BETWEEN GEOMORPHIC SURFACES
A	UPLAND SURFACE
B	DISSECTED TERRACE
C	PITTED GLACIAL-FLUVIAL SURFACE
D	RIVER LOWLAND

NOTE:
THIS DRAWING SHOWS ONLY THE PRIVATE WELLS THAT ARE BETWEEN 1200' AND 1300' FROM THE PROPOSED LIMITS OF WASTE PLACEMENT. ALL OTHER PRIVATE WELLS ARE LOCATED AT A DISTANCE GREATER THAN 1300' FROM THE PROPOSED LIMITS OF WASTE PLACEMENT.

FOTH & VAN DYKE
GEOSCIENCES & ENVIRONMENTAL MANAGEMENT DIVISION
GREEN BAY, WISCONSIN

	BY	DATE
DESIGN		
DRAWN	DHS	11/89
CHK'D	JWS	11/89
DES. ENG'R		
SEC' ENG'R		

FLAMBEAU PROJECT
LADYSMITH, WISCONSIN

KENNECOTT MINERALS COMPANY
155 MINERAL SQUARE
SALT LAKE CITY, UTAH
8412

FIGURE NO. 3-1
ONE TIME DISPOSAL
SITE LOCATION

MICROFILM | JOB
DRAWING NO. | REV.
DIVISION DRAWING NO.
SCALE | SEE BAR SCALE

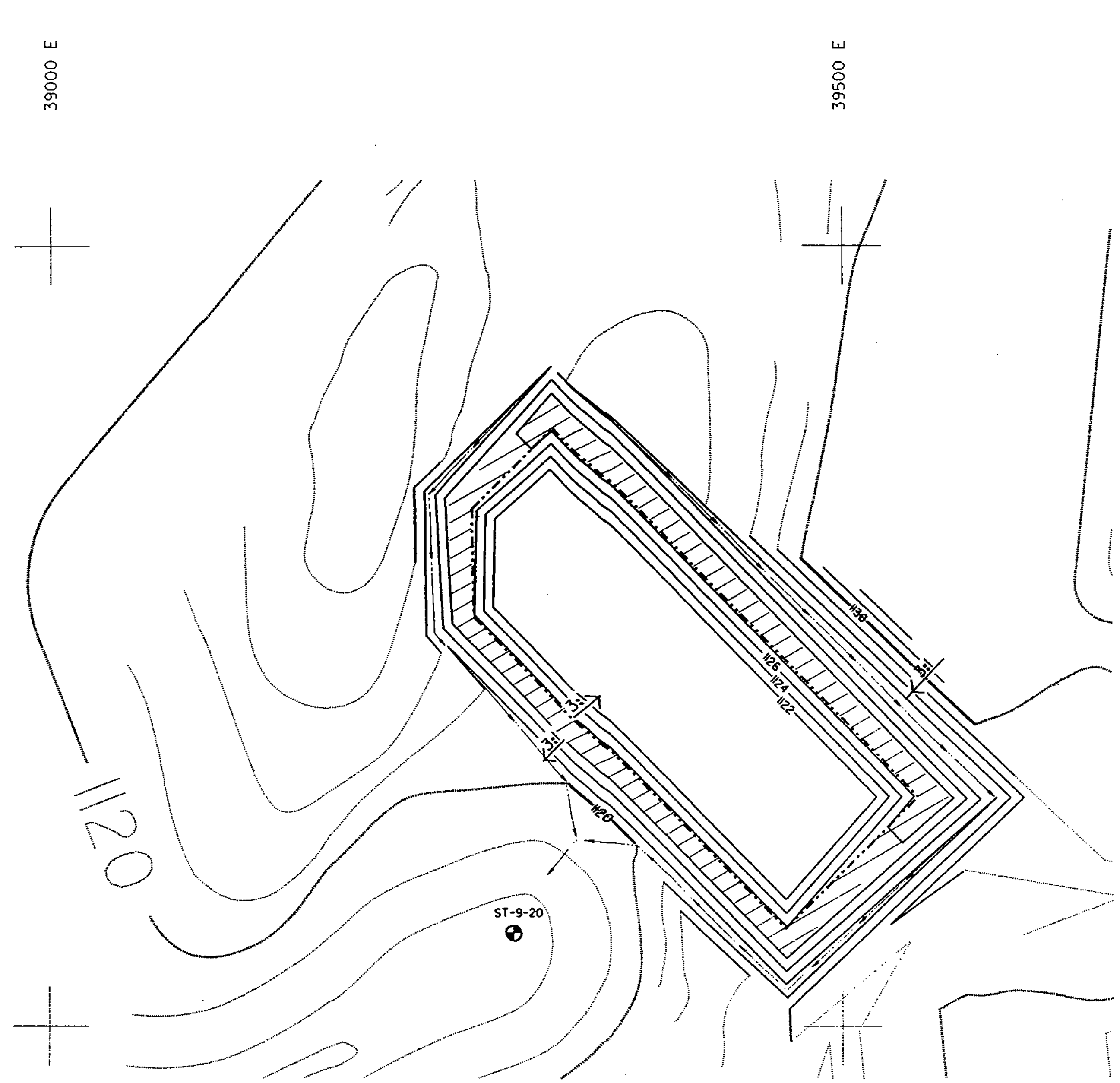
REFERENCES	DWG. NO.	DESCRIPTION

REFERENCES	DWG. NO.	DESCRIPTION

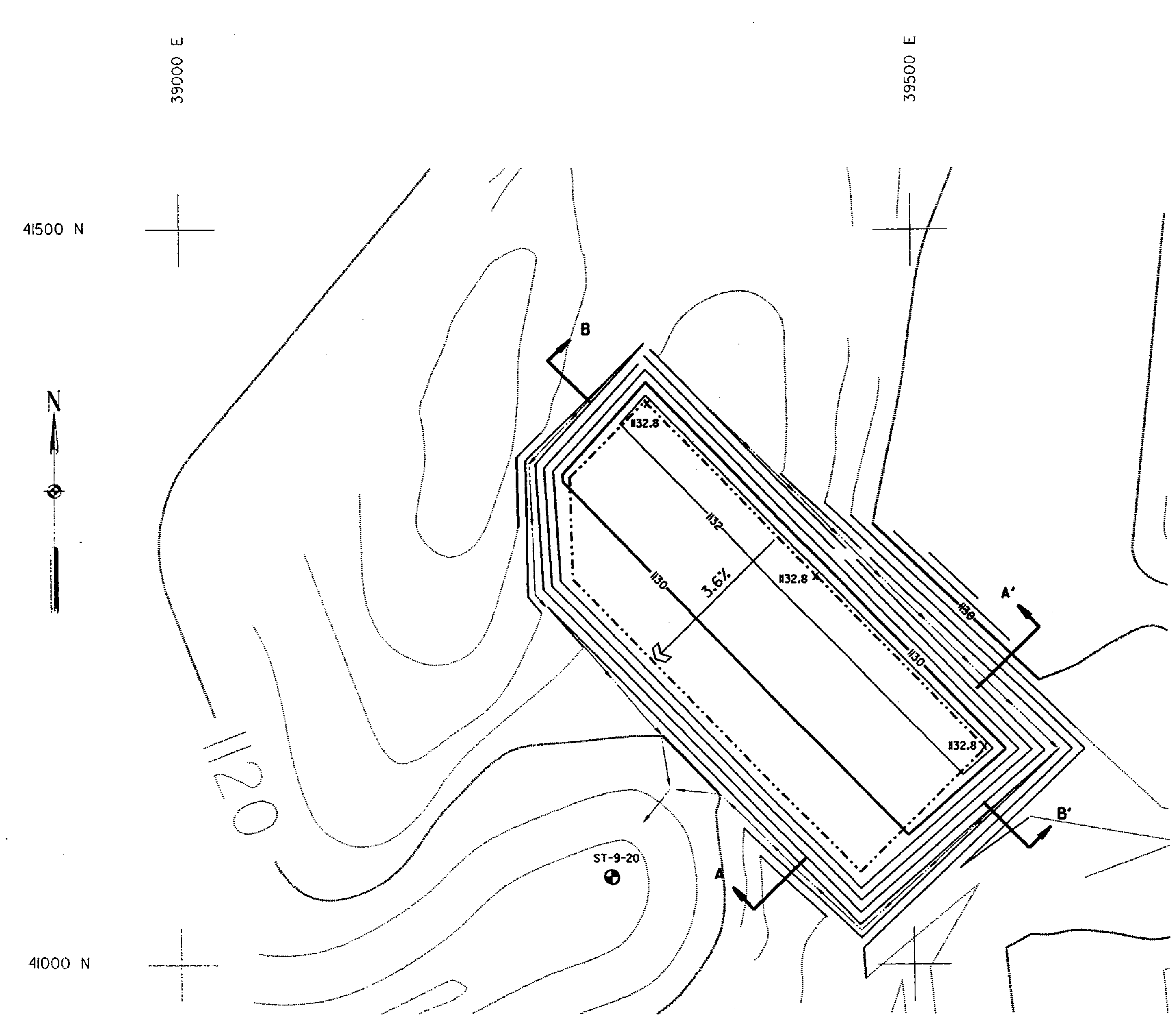
NO.	DATE	REVISIONS	BY	CHK'D	ENG'R	ENG'R MGR.

NO.	DATE	REVISIONS	BY	CHK'D	ENG'R	ENG'R MGR.

	BY	DATE
PROJ. ENG'R		
MGR. PROCESS ENG'R		
ENG'R MGR.		



BASE GRADES



FINAL GRADES

LEGEND

---1120---	RECLAIMED SITE FINAL GRADE CONTOUR	———	PROPOSED DRAINAGE SWALE
4%	PROPOSED SLOPE	x 1132.8	PROPOSED SPOT ELEVATION
3:1	PROPOSED SLOPE RATIO	▨	TOP OF BERM
—··—··	PROPOSED LIMITS OF WASTE PLACEMENT	ST-9-20	SOIL BORING LOCATION AND NUMBER
—1130—	PROPOSED CONTOUR		

0 50' 100'
SCALE

NOTES:

1. SITE LOCATION: THE NE 1/4 OF SECTION 9 T34N, R6W, RUSK COUNTY, WISCONSIN.
2. TOPOGRAPHIC BASE MAP PREPARED FROM THE FLAMBEAU MINING COMPANY MINING PERMIT APPLICATION, FIGURE NO. 5-3 TITLED RECLAIMED SITE FINAL GRADING PLAN.
3. ELEVATIONS BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS TWO FEET.
4. HORIZONTAL DATUM BASED ON PROJECT SITE GRID SYSTEM. SITE GRID COORDINATES CORRELATION TO STATE PLANE COORDINATES DERIVED AS FOLLOWS:

SITE GRID COORDINATES CONTROL MONUMENT F-1	STATE PLANE COORDINATES
40000 N =	587,357.8087 N
40000 E =	1,713,516.1229 E

THE ANGULAR ROTATION FROM STATE PLANE BEARINGS TO GRID BEARINGS IS 359°-13'-23" RIGHT WITH CONTROL CONTROL POINT F-1 AS THE BASE POINT.

FOTH & VAN DYKE
GEOSCIENCES & ENVIRONMENTAL MANAGEMENT DIVISION
GREEN BAY, WISCONSIN

FLAMBEAU PROJECT
LADYSMITH, WISCONSIN

KENNECOTT MINERALS COMPANY
155 MINERAL SQUARE
SALT LAKE CITY, UTAH
8412

FIGURE NO. 4-1
DEMOLITION SITE
BASE GRADES / FINAL GRADES

	BY	DATE
DESIGN	MJO	12/89
DRAWN	DHS	12/89
CHK'D	JWS	12/89
DES. ENG'R		
SECT ENG'R		

	BY	DATE
PROJ. ENG'R		
MGR. PROCESS ENG'R		
ENG'R MGR.		

MICROFILM | JOB
DRAWING NO. | REV.
DIVISION DRAWING NO.
SCALE | SEE BAR SCALE

REFERENCES

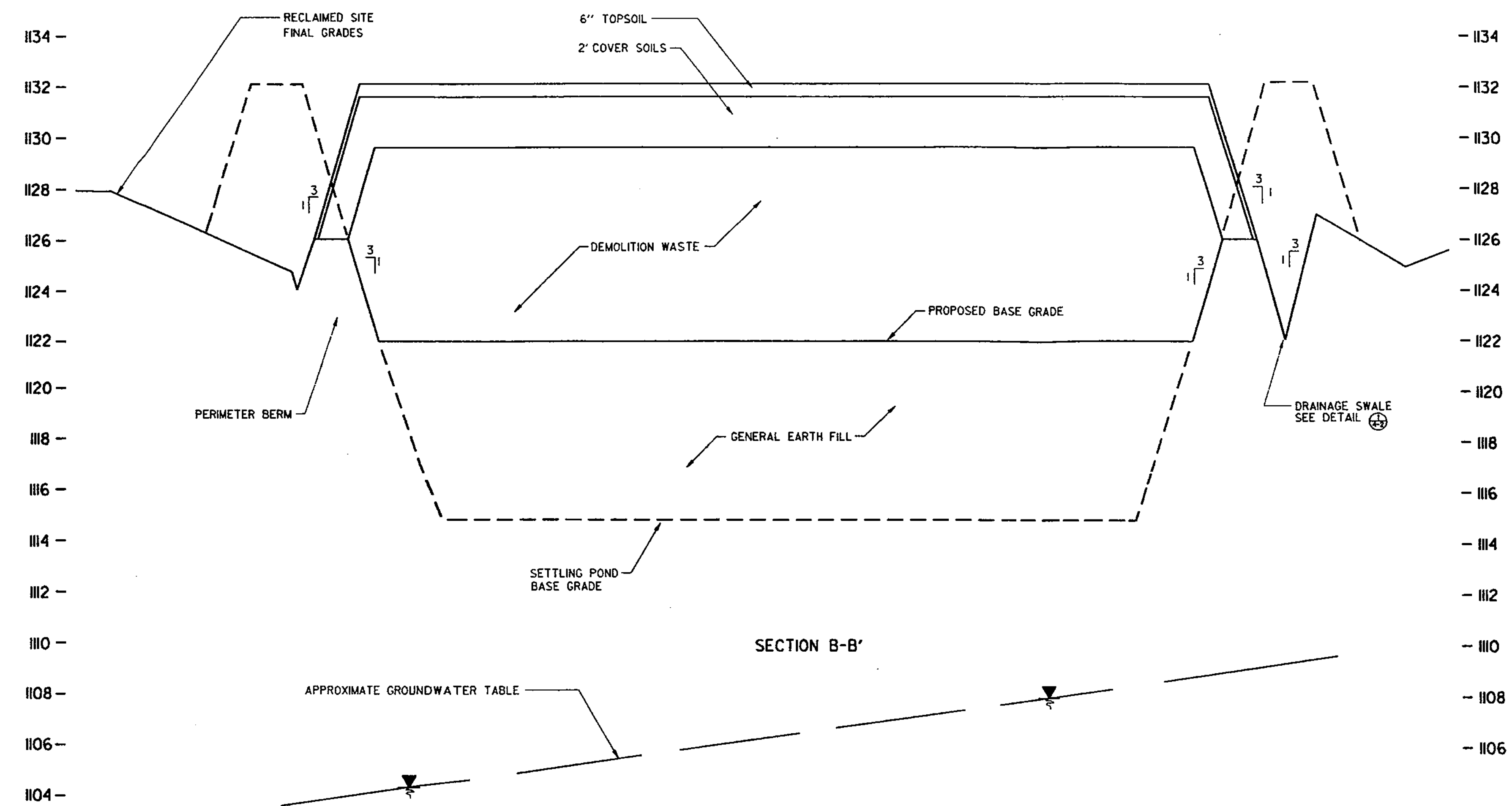
DWG. NO.	DESCRIPTION

REFERENCES

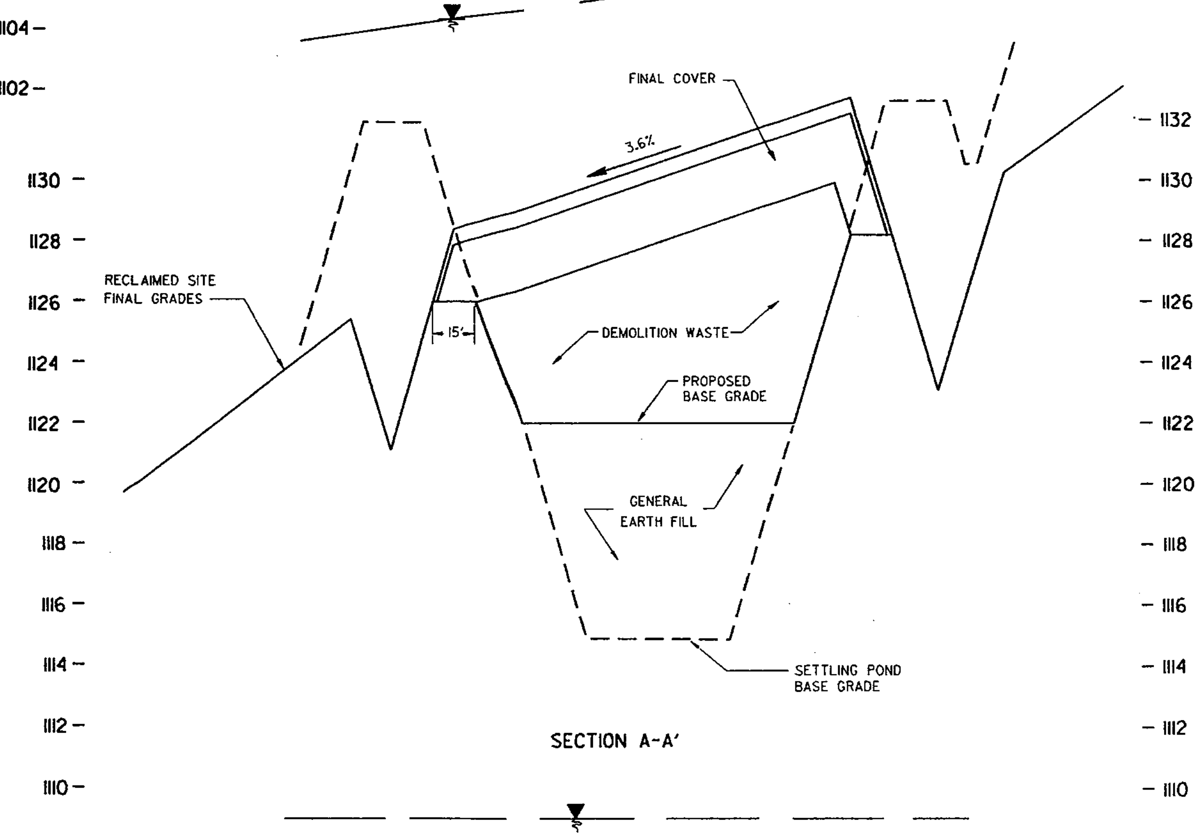
DWG. NO.	DESCRIPTION

NO.	DATE	REVISIONS	BY	CHK'D	ENG'R	ENG'R MGR.

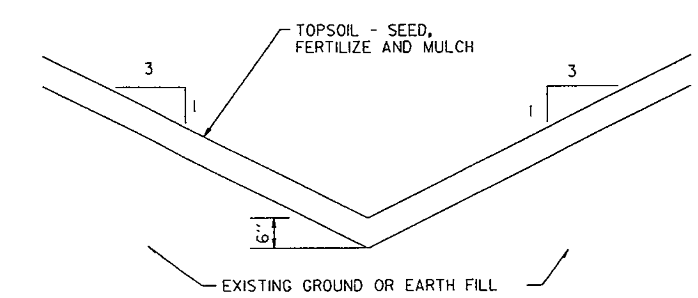
NO.	DATE	REVISIONS	BY	CHK'D	ENG'R	ENG'R MGR.



SECTION B-B'



SECTION A-A'

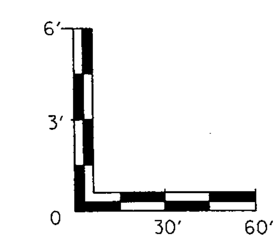


1/4-2 TYPICAL DRAINAGE SWALE DETAIL

NOT TO SCALE

NOTES:

1. SEE FIGURE NO. 4-1 FOR CROSS SECTION LOCATIONS.
2. GROUNDWATER ELEVATIONS TAKEN FROM FIGURE NO. 3.6-4 HIGH WATER TABLE CONTOUR MAP APRIL 6, 1988 OF THE ENVIRONMENTAL IMPACT REPORT FOR THE KENNECOTT FLAMBEAU PROJECT DATED APRIL, 1989.
3. THE ENTIRE DISPOSAL FACILITY IS LOCATED IN A WELL GRADED SAND. REFER TO THE AREA 220' TO THE NORTHEAST OF BORING ST-9-20 ON FIGURE NO. 3.5-9 GEOLOGIC CROSS SECTION G-G' OF THE ENVIRONMENTAL IMPACT REPORT FOR THE KENNECOTT FLAMBEAU PROJECT DATED APRIL, 1989. THEREFORE NO SITE GEOLOGY IS SHOWN ON THIS DRAWING.



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FLAMBEAU PROJECT
LADYSMITH, WISCONSIN

KENNECOTT MINERALS COMPANY
155 MINERAL SQUARE
SALT LAKE CITY, UTAH 8412

FIGURE NO. 4-2
DEMOLITION SITE
ENGINEERING CROSS SECTIONS

	BY	DATE
DESIGN	MJO	12/89
DRAWN	DHS	12/89
CHK'D	JWS	12/89
DES. ENG'R		
SECT ENG'R		

	BY	DATE
PROJ. ENG'R		
MGR. PROCESS ENG'R		
ENG'R MGR.		

MICROFILM	JOB
DRAWING NO.	REV.
DIVISION DRAWING NO.	
SCALE	SEE BAR SCALE

REFERENCES	DWG. NO.	DESCRIPTION

REFERENCES	DWG. NO.	DESCRIPTION

NO.	DATE	REVISIONS	BY	CHK'D	ENG'R	ENG'R MGR.

NO.	DATE	REVISIONS	BY	CHK'D	ENG'R	ENG'R MGR.

APPENDIX L

Prediction of Groundwater Quality Downgradient of the Reclaimed Pit for the Kennecott Flambeau Project, Revised December 1989

The report titled "Prediction of Groundwater Quality Downgradient of the Reclaimed Pit for the Flambeau Project" included in this Appendix is a revision of the report with the same title dated July 1989. Revisions made to the July 1989 report primarily relate to projections of precipitate volume from the wastewater treatment plant. The modeling completed for the July 1989 report was based on a projected wastewater treatment plant precipitate generation rate of 9,000 dry pounds of solids per one million gallons of treated water. Based on information presented in the revised Mining Permit Application for the project dated December 1989, it is currently projected that precipitate will be generated by the planned wastewater treatment plant at the rate of approximately 11,100 dry pounds per one million gallons of treated water. The revision to projected precipitate generation results in minor changes to the time frames presented in Table No. 2-5. The revisions do not change the predicted parameter concentrations, nor do they change the conclusions of the report.

PREDICTION OF GROUNDWATER QUALITY DOWNGRADIENT OF THE RECLAIMED PIT FOR THE FLAMBEAU PROJECT

Prepared for:

FLAMBEAU MINING COMPANY

Prepared by:

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P.O. Box 19012
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REVISED DECEMBER 1989

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FAX: 414/497-8516

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1.0 INTRODUCTION

This report addresses whether or not groundwater quality impacts will result from the reclamation of the open mine pit that will be created as part of the Flambeau Project near Ladysmith, Wisconsin. This question was initially addressed in the environmental impact report (KEIR) (Foth & Van Dyke 1989a) for this project. Supplementary information on groundwater flow directions and velocities during and after mining have been provided in a modeling report by Prickett (1989). The groundwater quality impact of the Type I stockpile was demonstrated to be insignificant in another supplementary report, by Foth & Van Dyke (1989b).

The KEIR concludes that neither the mining operation, itself, nor the creation and operation of the Type II stockpile will create groundwater quality impacts. The mine pit, when in existence, will cause the formation of a cone of depression in the water table. Thus, during the time the mine is in existence, all groundwater will flow toward the open pit, making it impossible for any groundwater-borne compounds to leave the mine vicinity. As for the Type II stockpile, it will be underlain with an impervious liner and a leachate collection system, thereby preventing compounds from moving downward from the stockpile to the water table. Underneath the stockpile, therefore, no groundwater-borne compounds will be able to move downward to the water table.

Since the mine pit as well as both the stockpiles are incapable of impacting groundwater quality, the only remaining groundwater quality issue, then, is the one relating to the reclaimed pit. The waste characterization study described in the KEIR showed the possibility that several parameters in the reclaimed pit could become elevated. This report determines that four of these--copper, manganese, iron, and sulfate--would be elevated sufficiently to be measurable and predictable. These concentrations would occur in the bottom of the pit in the layer of Type II waste rock, the most leachable of the materials returned to the pit.

In order to evaluate what, if any, impact these compounds will have on water quality, it is necessary to consider the results of the modeling conducted by Prickett (1989). He, assisted by the staff of Engineering Technologies Associates, Inc. of Ellicott City, Maryland, created a two-dimensional, cross-sectional flow model of the reclaimed pit. This model clearly shows that the groundwater within the waste rock below the saprolite layer in the reclaimed pit flows downwards and toward the river pillar. He showed that as long as the river pillar is relatively highly permeable, the pillar itself acts as a sink, drawing all the up-gradient bedrock groundwater toward it, and then discharging it to the river at an average discharge rate of 2 gallons per minute (gpm).

The only situation which could change this flow pattern would be a change in the river pillar permeability, caused by grouting during mining operations. If such a permeability change would occur, the potential would exist for a small amount of the groundwater emanating from the Type II waste rock in the reclaimed pit to move upward past the saprolite layer and escape the pit in the shallow outwash to the northwest.

Such grouting would occur, however, only in response to a need to cut down flows to the open pit so as not to overload the wastewater treatment plant. Inasmuch as the wastewater treatment plant has been significantly over-designed with respect to capacity, there is no possibility that a grouting effort will ever be undertaken to reduce the flows through the river pillar to less than those predicted by Prickett. The wastewater plant is designed to handle the flows he predicted, and more.

Therefore, since there is no likelihood that the pillar permeability will ever be reduced to a level below that used by Prickett in his predictions, there also is no possibility that the groundwater emanating from the Type II waste rock in the reclaimed pit will do anything but move straight toward the Flambeau River through the river pillar. Thus, the only flow regime evaluated in this report is the direct route through the river pillar. The studies described herein conclude that only one parameter, sulfate, would depart the reclaimed pit at concentrations higher than present-day background groundwater quality conditions. The report further concludes that the sulfate concentration increase would not be of concern because no sulfate increase would be detectable beyond the Flambeau River. Since the proposed compliance boundary is beyond the river, no sulfate exceedences are possible at the point of standards application. As to the river itself, the incremental increases in the river water of parameters in groundwater entering the river from the pit will be so small as to be unmeasurable. Thus, no impact on the river will occur.

Following this introduction, Section 2.0 of the report discusses how the source term concentrations for copper, manganese, iron, and sulfate were derived. Section 3.0 discusses the transport of these constituents downgradient of the pit through the river pillar and into the river. Section 4.0 of the report presents the report's evaluation of the potential impacts. Section 5.0 is a list of the references cited.

2.0 SOURCE TERM CALCULATIONS

Type II wastes, consisting of saprolite and waste rock containing more than one percent sulfur, will be temporarily stockpiled above grade in a lined, twenty-seven acre site. Reactions between the stockpiled wastes and precipitation produce leachate which will be collected and treated, along with pit contact water, in an on-site wastewater treatment facility. The slurried lime and sulfide precipitate produced in the facility will be spread on the stockpiled wastes. The precipitate reacts with the leachate in the stockpile, forming additional leachate by dissolution and secondary minerals by precipitation.

Following the completion of mining operations, these wastes and precipitates will be backfilled into the bottom of the open pit. As these materials are being backfilled, groundwater and precipitation will restore the groundwater levels to the approximate premining steady state elevations. When the steady state groundwater levels have been attained, groundwater will flow from the east to the west through the backfilled materials within the pit. Reactions between the groundwater and the wastes will result in the release of certain substances from the wastes to the groundwater which will then be transported with the groundwater from the pit.

The models described in this report include one which formulates the generation of the leachate within the stockpiled wastes, and one which formulates the reactions between the backfilled wastes and groundwater. Also discussed are the generation of the Type II wastes and the precipitate, and the expected reactions between the stockpiled wastes and the applied slurried precipitate.

The output of the first model is a time-based generation of leachate within the stockpiled wastes. The output of the second model is a time-based release of substances from the backfilled pit to the downgradient groundwater.

2.1 <u>Model Inputs</u>

The inputs to the model describing the unsaturated generation of leachate within the stockpiled wastes include the quantity of waste stored in the stockpile and the time during which the wastes are added to the stockpile. In addition, the quantity and periodicity of the precipitative inputs to the stockpile are utilized in the model. The leachate percolates through the wastes until it intersects the leachate collection system which will be installed beneath the system and above the impervious liner.

The leachate thus generated and collected will be piped to the surge pond. From there it will be sent to the wastewater treatment facility where, along with the pit contact water, it will be treated with lime and sulfide. This treatment removes substances to a level which will more than meet the requirements for the discharge of these waters to the Flambeau River. A by-product of the treatment will be the generation of sulfide precipitate produced from lime. This precipitate will be applied to the stockpiled wastes in a slurried form on a daily basis. The precipitate applied to the stockpile will react with precipitation and leachate producing additional leachate of a somewhat alkaline nature and secondary minerals.

The quantity and composition of the backfilled wastes and precipitates returned to the pit, and the quantity and composition of the recharging groundwater and precipitation, are the inputs for the model that predicts the in-pit reactions between the wastes and groundwater.

2.1.1 Type II Waste Generation

Type II waste materials will be generated in two phases. The first phase, Phase I, will consist of waste rock and saprolite removed from the western half of the open pit. Phase II wastes will consist of the same materials, but will differ in relative proportions of them. The Phase II wastes will be removed from the eastern end of the pit subsequent to the removal of the Phase I wastes, as shown on Table No. 4-2 of the Revised *Mining Permit Application for the Flambeau Project* (KMINE) (Foth & Van Dyke 1989c).

As seen in Table No. 2-1, a total of 3,122 kilotons of Type II waste will be removed during the mining operation. All of these wastes will be stockpiled in the lined Type II stockpile. Quarterly production figures for the combined Phase I and II wastes are also listed in Table No. 2-1. The wastes will be stockpiled in two phases, the first of which, Phase I, will cover 15.53 acres. Phase II of the stockpiling will cover an additional 11.47 acres. Phase I stockpiling will initially occur through the third quarter of the second year of operations. From that time until the cessation of operations at the end of the third quarter of the sixth year, stockpiling at various rates will occur in both phases, but mainly in the Phase II area.

2.1.2 Leachate Generation

The most important factor in leachate generation is the input of precipitation to the stockpiled wastes. Average monthly precipitation data, corrected for losses due to evapotranspiration, were added to the wastes on a quarterly basis in the model (see KMINE, Appendix N, p. 28 for data). The quarters used in the model were January-March, April-June, July-September, and, October-December. In the model it was assumed that the net

TABLE NO. 2-1

In-Pit Model Output

PERIOD	WR II (ktons)	Precip. (L)	SULFATE (mg)	SULFATE (mg/L)	IRON (mg)	IRON (mg/L)	MANGANESE (mg)	MANGANESE (mg/L)	COPPPER (mg)	COPPPER (mg/L)
PP-1	0	5.26E+06	0.00E+00		0.00E+00		0.00E+00		0.00E+00	
PP-2	234	7.49E+06	2.97E+11	3.96E+04	3.57E+10	4.77E+03	8.20E+08	1.09E+02	9.28E+10	1.24E+04
1-1	130	8.68E+06	2.52E+11	2.90E+04	2.81E+10	3.24E+03	7.08E+08	8.16E+01	7.84E+10	9.03E+03
1-2	128	6.14E+06	2.52E+11	4.10E+04	2.76E+10	4.50E+03	7.12E+08	1.16E+02	7.84E+10	1.28E+04
1-3	107	5.27E+06	2.32E+11	4.40E+04	2.47E+10	4.69E+03	6.60E+08	1.25E+02	7.16E+10	1.36E+04
1-4	112	7.49E+06	2.36E+11	3.15E+04	2.50E+10	3.34E+03	6.72E+08	8.97E+01	7.28E+10	9.72E+03
2-1	119	8.68E+06	2.47E+11	2.84E+04	2.62E+10	3.02E+03	7.04E+08	8.11E+01	7.64E+10	8.80E+03
2-2	55	6.14E+06	1.71E+11	2.78E+04	1.69E+10	2.75E+03	4.96E+08	8.08E+01	5.24E+10	8.53E+03
2-3	66	5.27E+06	1.65E+11	3.13E+04	1.65E+10	3.13E+03	4.76E+08	9.03E+01	5.05E+10	9.56E+03
2-4	56	1.30E+07	1.47E+11	1.13E+04	1.45E+10	1.12E+03	4.28E+08	3.29E+01	4.52E+10	3.48E+03
3-1	130	1.51E+07	2.35E+11	1.56E+04	2.52E+10	1.67E+03	6.68E+08	4.42E+01	7.24E+10	4.79E+03
3-2	204	1.09E+07	3.53E+11	3.24E+04	3.88E+10	3.56E+03	9.96E+08	9.14E+01	1.09E+11	1.00E+04
3-3	204	9.16E+06	3.92E+11	4.28E+04	4.24E+10	4.63E+03	1.11E+09	1.21E+02	1.21E+11	1.32E+04
3-4	196	1.07E+07	4.02E+11	3.09E+04	4.28E+10	3.29E+03	1.14E+09	8.77E+01	1.24E+11	9.54E+03
4-1	202	1.51E+07	4.18E+11	2.77E+04	4.44E+10	2.94E+03	1.19E+09	7.88E+01	1.29E+11	8.54E+03
4-2	206	1.09E+07	4.32E+11	3.96E+04	4.56E+10	4.18E+03	1.23E+09	1.13E+02	1.33E+11	1.22E+04
4-3	217	9.16E+06	4.55E+11	4.97E+04	4.80E+10	5.24E+03	1.30E+09	1.42E+02	1.40E+11	1.53E+04
4-4	212	1.30E+07	4.58E+11	3.52E+04	4.80E+10	3.69E+03	1.31E+09	1.01E+02	1.41E+11	1.08E+04
5-1	191	1.51E+07	4.36E+11	2.89E+04	4.48E+10	2.97E+03	1.25E+09	8.28E+01	1.34E+11	8.87E+03
5-2	108	1.09E+07	3.27E+11	3.00E+04	3.18E+10	2.92E+03	9.52E+08	8.73E+01	1.00E+11	9.17E+03
5-3	58	9.16E+06	2.33E+11	2.54E+04	2.11E+10	2.30E+03	7.12E+08	7.77E+01	7.08E+10	7.73E+03
5-4	60	1.30E+07	2.02E+11	1.55E+04	1.84E+10	1.42E+03	6.00E+08	4.62E+01	6.12E+10	4.71E+03
6-1	61	1.51E+07	1.87E+11	1.24E+04	1.71E+10	1.13E+03	5.52E+08	3.66E+01	5.68E+10	3.76E+03
6-2	43	1.09E+07	1.54E+11	1.41E+04	1.37E+10	1.26E+03	4.60E+08	4.22E+01	4.68E+10	4.29E+03
6-3	23	9.16E+06	1.16E+11	1.30E+04	9.52E+09	1.04E+03	3.51E+08	3.83E+01	3.48E+10	3.80E+03
6-4	0	1.30E+07	7.12E+10	5.48E+03	4.68E+09	3.60E+02	2.25E+08	1.73E+01	2.10E+10	1.62E+03
7-1	0	1.51E+07	5.35E+10	3.54E+03	3.20E+09	2.12E+02	1.73E+08	1.15E+01	1.56E+10	1.03E+03
7-2	0	1.09E+07	4.32E+00	3.96E+03	2.42E+09	2.22E+02	1.42E+08	1.30E+01	1.26E+10	1.16E+03
TOTALS:			6.92E+12		7.17E+11		2.00E+10		2.14E+12	

precipitation was of uniform quantity during the entire quarter. Also, it was assumed that runoff would generate leachate, since it will be in contact with the wastes and will be collected by part of the leachate collection system.

The precipitation and runoff that will be collected by the Phase I stockpile for the above listed quarters will be 6.14×10^6, 5.27×10^6, 7.49×10^6, and, 8.68×10^6 liters per quarter, respectively. The precipitation and runoff that will be collected by the combined Phase I and II stockpiled wastes will be 1.09×10^7, 9.16×10^6, 1.30×10^7, and, 1.51×10^7 liters per quarter, respectively (see Table No. 2-1).

Wet-dry leaching experiments were performed on a typical Type II waste (sample WR-5) as part of the waste characterization studies. These experiments simulate the reactions that will occur when precipitation reacts with the wastes. Mathematical relationships have been developed between the quantity of five parameters--copper, iron, manganese, sulfate, and pH--that will be leached from these materials, and the leach cycle number (see Table Nos. 3.5-18 and 3.5-19 in the KEIR). No other relationships were developed because no other parameters that would be of concern leached from the waste rock in any elevated concentration.

Each leaching test was conducted for a period of 80 days during which time leachate samples were collected and analyzed following a geometrically increasing time scale (samples were collected at the conclusion of cycles 1, 2, 4, 8, and, 16). The results of the analyses of these samples has revealed that the quantities of materials leached decreased according to negative power functions of the leaching cycles. The calculated numerical relationships for the leaching of the rock chips, which will make up an estimated 97-98 percent of the stockpiled waste rock, are:

$$\text{Cu (ug/g)} = (437.6)(\text{cycle \#})^{-1.81}, \qquad r^2 = 0.93$$
$$\text{Fe (ug/g)} = (168.0)(\text{cycle \#})^{-2.11}, \qquad r^2 = 0.93$$
$$\text{Mn (ug/g)} = (3.86)(\text{cycle \#})^{-1.71}, \qquad r^2 = 0.94$$
$$SO_4 \text{ (mg/g)} = (1.40)(\text{cycle \#})^{-1.78}, \qquad r^2 = 0.92$$

The numerical relationship between leachate pH, which was measured during each of the 16 cycles, and leaching cycle number is:

$$\text{pH (su)} = (2.86)(\text{cycle \#})^{0.14}, \qquad r^2 = 0.92$$

Similar relationships were observed for the leaching of the rock powder. However, due to irregularities in the data, only the leached amounts of copper and manganese could be quantified simply. The calculated relationships for these metals are:

$$\text{Cu (ug/g)} = (314.8)(\text{cycle \#})^{-1.13}, \qquad r^2 = 0.81$$
$$\text{Mn (ug/g)} = (2.64)(\text{cycle \#})^{-1.54}, \qquad r^2 = 0.88$$

Due to the fact that only a minor proportion of the waste rock will be powder, and the fact that the leaching relationships of the powder are similar to the rock chips, only the data from the rock chip leaching experiments have been used in modeling the leachate generation.

The results of the analyses also revealed that significant statistical mathematical relationships exist between the quantities of leached copper, iron, manganese, and, sulfate and leachate pH. These calculated relationships show that the quantities of metals leached from the rock chips decrease with increasing pH following negative power functions. These relationships are:

$$Cu\ (ug/g) = (7.45 \times 10^{8})(pH)^{-13.7}, \qquad r^2 = 0.95$$
$$Fe\ (ug/g) = (3.25 \times 10^{8})(pH)^{-16.0}, \qquad r^2 = 0.97$$
$$Mn\ (ug/g) = (2.96 \times 10^{5})(pH)^{-12.9}, \qquad r^2 = 0.97$$
$$SO_4\ (mg/g) = (2.42 \times 10^{6})(pH)^{-13.6}, \qquad r^2 = 0.98$$

It is assumed that the leaching characteristics of the Type II saprolite will be similar to that of the waste rock.

2.1.3 Precipitate Generation

Bench tests performed as part of the *Preliminary Engineering Report for Wastewater Treatment Facilities* (Foth & Van Dyke 1989d) have shown that precipitate production from the planned wastewater treatment plant will vary with the length of exposure of Type II material to wetting and drying cycles. Precipitate production during the studies ranged from 9,000 pounds of dry precipitate per million gallons of wastewater to 60,000 pounds per million gallons. The higher value corresponds to the initial wetting of Type II material used for the bench tests, while the lower value represents the third and final wetting. The second wetting produced an estimated production rate of 30,000 dry pounds per million gallons.

Given the bench test results, it is projected that the actual rate of precipitate production at the maximum wastewater treatment plant capacity of 800 gpm will be closer to 30,000 dry pounds per million gallons. At the estimated average annual flow rate of 296 gpm, average daily precipitate production over the life of the project is expected to be equivalent to approximately 11,100 dry pounds per million gallons.

The projected quarterly generation of wastewater from the open pit and Type II stockpile are listed in Table No. 2-2. The values for the pit inflow data were derived from Prickett (1989). The other values were calculated from data presented in the KMINE document. The values take into account the changes in pit inflow, variations in quarterly precipitation and runoff (listed as "precipitation"), the successive opening of Phases I and II within the pit, and the expansion of the stockpile when Phase II of the stockpile is opened.

For modeling it was conservatively assumed that the composition of the wastewater emanating from the open pit will be approximately equivalent to the average Type II waste rock leachate. The composition of the pit contact wastewater is considered to be equivalent to the cycle 8 waste rock leachate (see Table No. 3.5-19, KEIR), which is:

$$\begin{aligned} Cu &= 24{,}000 \text{ ug/L} \\ Fe &= 4{,}200 \text{ ug/L} \\ Mn &= 210 \text{ ug/L} \\ SO_4 &= 60 \text{ mg/L} \end{aligned}$$

The average steady state pit contact water flow is 8.47×10^7 liters per quarter. Pit contact water will be collected for twenty-five quarters. It has been determined that 5.08×10^{10}, 8.90×10^9, 4.45×10^8, and, 1.27×10^{11} mg of copper, iron, manganese, and, sulfate, respectively, will be leached from the pit contact rocks. Stockpile leachate will be collected for twenty-eight quarters and, as shown in Table No. 2-1, 2.14×10^{12}, 7.17×10^{11}, 2.00×10^{10}, and, 6.90×10^{12} mg of copper, iron, manganese, and, sulfate, respectively, will be leached from the stockpiled Type II wastes. Of all the metal loading, 2.3, 1.2, 2.2, and 1.8 percent, respectively, will be derived from the pit contact water.

TABLE NO. 2-2

Quarterly Generation of Pit Contact Water, Stockpile Leachate, and Slurried Precipitate

PERIOD	Pit Inflow (L)	Pit Precip. (L)	Pit Total (L)	Stockpile Leachate (L)	Slurried Precip. (L)
PP-1	3.73E+06	8.40E+06	1.21E+07	0.00E+00	0.00E+00
PP-2	1.14E+07	2.14E+07	3.28E+07	7.49E+06	1.12E+05
1-1	1.91E+07	1.13E+07	3.04E+07	8.68E+06	1.09E+05
1-2	2.66E+07	6.48E+06	3.31E+07	6.14E+06	1.09E+05
1-3	3.31E+07	1.68E+07	4.99E+07	5.27E+06	1.53E+05
1-4	3.85E+07	4.28E+07	8.13E+07	7.49E+06	2.47E+05
2-1	4.40E+07	2.25E+07	6.65E+07	8.68E+06	2.08E+05
2-2	4.92E+07	1.30E+07	6.22E+07	6.14E+06	1.90E+05
2-3	5.67E+07	3.36E+07	9.03E+07	5.27E+06	2.65E+05
2-4	5.67E+07	4.28E+07	9.95E+07	1.30E+07	3.64E+05
3-1	5.67E+07	2.24E+07	7.91E+07	1.51E+07	2.61E+05
3-2	5.67E+07	1.30E+07	6.97E+07	1.09E+07	2.23E+05
3-3	5.67E+07	3.36E+07	9.03E+07	9.16E+06	2.76E+05
3-4	5.67E+07	4.28E+07	9.95E+07	1.30E+07	3.64E+05
4-1	5.67E+07	2.25E+07	7.92E+07	1.51E+07	2.61E+05
4-2	5.67E+07	1.30E+07	6.97E+07	1.09E+07	2.23E+05
4-3	5.67E+07	3.36E+07	9.03E+07	9.16E+06	2.76E+05
4-4	5.67E+07	4.28E+07	9.95E+07	1.30E+07	3.64E+05
5-1	5.67E+07	2.25E+07	7.92E+07	1.51E+07	2.61E+05
5-2	5.67E+07	1.30E+07	6.97E+07	1.09E+07	2.23E+05
5-3	5.67E+07	3.36E+07	9.03E+07	9.16E+06	2.76E+05
5-4	5.67E+07	4.28E+07	9.95E+07	1.30E+07	3.64E+05
6-1	5.67E+07	2.25E+07	7.92E+07	1.51E+07	2.61E+05
6-2	5.67E+07	1.30E+07	6.97E+07	1.09E+07	2.23E+05
6-3	5.67E+07	3.36E+07	9.03E+07	9.16E+06	2.76E+05
6-4				1.30E+07	3.61E+04
7-1				1.51E+07	4.19E+04
7-2				1.09E+07	3.02E+04
TOTALS:	1.19E+09	6.24E+08	1.81E+09	2.87E+08	6.00E+06

In terms of flow, the waste rock leachate comprises only an average of 12.5 percent of the water that will be treated in the wastewater treatment facility. The difference in material loading between the pit and stockpile sources can be attributed to the fact that the stockpiled wastes are leached through many successive cycles and to the very considerable exposed surface area per unit mass of the stockpiled waste.

The precipitate will consist of metal hydroxides, sulfides and sulfates. Iron will be precipitated as a hydroxide, nearly all of the copper will be precipitated as a hydroxide, and approximately 75 percent of the manganese will be precipitated as a sulfide (the remaining manganese will be precipitated as a hydroxide). Sulfate will be precipitated as the mineral gypsum (a hydrous calcium sulfate) during the lime treatment of the wastewater (see Larsen, et. al., 1973, and Lanoutte, 1977).

2.1.4 Stockpiled Type II Waste Reactions

Field studies have shown that numerous secondary minerals form within and on the surface of stockpiled sulfide wastes (Nordstrom, 1982, Whiting, 1985). Some of the minerals commonly found in the central portions of stockpiles where the rates of evaporation are slow include:

- ferrihydrite, a hydrous iron oxide
- calcanthite, a hydrous copper sulfate
- ilesite, a hydrous manganese sulfate
- malachite, a hydrous copper carbonate

A mineral commonly found near the margins of sulfide stockpiles where the rates of evaporation are greater and where the pH is lowest in the stockpile is:

- jarosite, a hydrous potassic iron sulfate

Secondary minerals that form by rapid evaporation are often found on the surface and edges of sulfide stockpiles, especially near areas where seepages occur. These minerals include:

- melanterite, a hydrous iron sulfate
- copiapite, a hydrous iron sulfate
- antlerite, a hydrous copper sulfate
- cuprocopiapite, a hydrous copper iron sulfate

Minerals that form on the surfaces of sulfide stockpiles tend to be soluble and are dissolved during rain storms. Minerals that form within stockpiles tend to have lower solubilities and persist and grow during the time that the stockpile is in existence.

It is expected that, with the exception of the formation of ferrihydrite, only minor amounts of copper, manganese and sulfate will become incorporated in secondary minerals that form within or on the stockpile. Ferrihydrite is a stable mineral under all but the most acidic conditions and forms rapidly from iron hydroxide precipitates. During the lifetime of the stockpile it is expected that nearly all of the iron hydroxide precipitate that will be spread on the stockpiled wastes will be converted to ferrihydrite (Schwertmann 1985).

The major secondary minerals that will be found within and on the stockpile will be the precipitates from the applied slurried wastewater precipitate. With the exception of the iron hydroxide precipitate (ferrihydrite), many of the precipitates will dissolve and contribute mass to the leachate. It is important to note that since the collection and treatment of the leachate will be continuous, and since the slurried precipitate will be applied to the stockpile daily, essentially all of the leached materials will be in solid form at the time that the weathered wastes are backfilled in the open pit. In addition, these solids, with the exception of ferrihydrite, will comprise the precipitate.

2.1.5 <u>In-Pit Type II Waste Reactions</u>

The saturated waste rock leaching studies were conducted in order to simulate the reactions that would occur if the waste materials were returned to the pit in untreated form. These materials had been previously leached during the wet-dry leaching studies. Synthetic groundwater approximating the concentration of upgradient groundwater was used to saturate the leaching columns (see Waste Characterization Studies in KEIR for details). No slurried precipitates were applied to the Type II leaching columns.

It was discovered that during the 16 saturated leaching cycles, pH decreased during the course of the leaching. In addition, the quantities of copper, manganese and sulfate leached from the waste rock chips increased. The quantity of iron leached from the chips at first increased and then decreased to the point that during cycles 8 and 16 iron was being sorbed from the synthetic groundwater (see Table No. 3.5-24 and 3.5-25 in the KEIR). The calculated relationships between leached copper, manganese and sulfate and the leach cycle number are positive power or exponential functions. These relationships are:

$$Cu\ (ug/g) = (18.4)(cycle\ \#)^{0.38}, \qquad r^2 = 0.92$$
$$Mn\ (ug/g) = (0.26)(cycle\ \#)^{0.41}, \qquad r^2 = 0.85$$
$$SO_4\ (mg/g) = (0.062)^{0.047(cycle\ \#)}, \qquad r^2 = 0.92$$
$$pH\ (su) = (3.77)(cycle\ \#)^{-0.051}, \qquad r^2 = 0.95$$

The calculated relationships between pH and the quantity of copper, manganese and sulfate leached from the rock chips are negative power functions. These mathematical relationships are not as statistically significant as were those of the wet-dry leachings. These relationships are:

$$Cu\ (ug/g) = (2.28 \times 10^5)(pH)^{-7.07}, \qquad r^2 = 0.84$$
$$Mn\ (ug/g) = (4.35 \times 10^3)(pH)^{-7.28}, \qquad r^2 = 0.74$$
$$SO_4\ (mg/g) = (13.7)(pH)^{-4.07}, \qquad r^2 = 0.60$$

These results suggest that the Type II wastes should be treated as they are returned to the pit. Therefore the effect of liming the wastes as they were being backfilled was investigated. In order to evaluate a worst case situation, freshly ground Type II waste rock (sample WR-5) was equilibrated with distilled, deionized water and with lime bearing water that raised the solution pH to 6.5, the approximate pH of the upgradient groundwater.

The results of the "acid neutralization" tests, given in Table No. 3.5-12 (see KEIR), show that liming reduced the original copper, iron and manganese concentrations by approximately 92, 95 and 24 percent, respectively, while the concentration of sulfate doubled. As a result of this study the mining plan calls for the addition of sufficient lime slurry to the Type II wastes as they are being backfilled in order to maintain a waste contact water pH of approximately 6.5.

The concentrations of copper, iron, manganese, and sulfate in the pit water will mainly be functions of the pH of the water and the quantity and relative solubilities of the materials that contain these parameters. The solubility of copper hydroxide is 2.2×10^{-2} mg/L and that of copper sulfide is 5.8×10^{-18} mg/L in pure water. The solubility of ferrous hydroxide is 8.9×10^{-1} mg/L and that of ferrous sulfide is 3.4×10^{-5} mg/L in pure water. At a pH of 6.5 ferric hydroxide will maintain concentrations of ferric iron at or below 3.2×10^{-1} mg/L. The solubility of manganese hydroxide is 1.2×10^{0} mg/L and that of manganese sulfide is 2.1×10^{-3} mg/L in pure water. The solubility of gypsum in pure water is 2.4×10^{3} mg/L. The solubilities of these substances will be suppressed in the pit contact water due to common ion effects.

From the above data, it is apparent that the concentration of these parameters will be dependent upon the solubilities of the soluble metal hydroxides and gypsum. The primary copper, iron and manganese sulfides, either as original rock constituents or as sulfide precipitates, are at least three orders of magnitude less soluble than their hydroxides. The solubilities of these hydroxides and sulfate, which constitute the bulk of the slurried precipitate, will control the concentrations of these parameters in the pit water and in the water that is flushed out of the pit by reestablished groundwater flow.

2.1.6 Model Input Summary

The leachate generation model provides a worst case appraisal of the leaching of the stockpiled Type II wastes. The wastes are stored by depositing successive layers of material upon one another in the lined site. The model summed the projected quantities that could be leached during cycle 1 with quantities that could be leached during cycle 2 in the next oldest quarterly deposit, and so on through all of the quarterly deposits.

The quantities of materials that could be leached from these wastes were determined in laboratory column experiments in which the wastes were successively leached with synthetic rain water, which is nearly pure water. These laboratory conditions simulated the maximum leaching that could occur, and might occur in the field, if the quarterly accumulations of waste were deposited side by side. However, the quarterly accumulations of stockpiled wastes will be essentially deposited one on top of the other.

Leachate generated by the reactions between precipitation and the uppermost layer will percolate into the next older layer beneath it. The leaching of the second, and successive layers beneath it, will be considerably less intense than if the leaching were conducted with rain water. The reduction in leaching will be due to the common ion effect, in which the leaching of a given substance will be suppressed by the presence of significant quantities of the substance to be leached in the leaching solution.

The solubility and quantity of the most soluble substance that contains the parameter of interest will control the concentration of the parameter in solution. This control will exist until all of the soluble material has dissolved. The remaining most soluble substance will then control the parameter concentration in solution.

The major control of the in-pit concentrations of copper, iron, manganese, and, sulfate will be the precipitates of copper hydroxide, iron hydroxide (and ferrihydrite), manganese hydroxide, and, hydrous calcium sulfate (gypsum). The other materials in the wastes and precipitate containing these substances are several orders of magnitude less soluble than those listed above. Dissolution of the less soluble substances will result in parameter concentrations of essentially background levels.

2.2 Model Outputs

The outputs of the leachate generation model and the in-pit model are discussed separately below. The outputs are time based releases of materials, by leaching or dissolution, to the leachate or groundwater, respectively.

2.2.1 Leachate Generation Model

The quantities of copper, iron, manganese, and, sulfate that will be included in the leachate will be a function of the quantity of waste rock leached during a given quarter, and the length of time that quantities of waste material have been in the stockpile. It was conservatively assumed that one significant leaching occurred during each quarter and that all of the material stockpiled during a given quarter was uniformly leached for the entire quarter.

The quantities of material leached was calculated by multiplying the quantity of waste deposited in the stockpile during a given period by the quantity of material that would be leached from the waste, considering the number of quarters that the materials were stockpiled. The total quantities that would be leached in a given quarter is the summation of the products of the mass of the waste times the appropriate leach cycle leaching. The results of these calculations are presented in Table No. 2-1.

The bulk concentration of copper, iron, manganese, and sulfate in the Type II waste (see Table No. 3.5-10 in the KEIR), multiplied by the total waste mass is the total quantity of each substance that potentially could be leached. These quantities are 1.81×10^{10}, 1.08×10^{11}, 5.38×10^{7}, and, 4.25×10^{8} grams respectively. The total projected quantities that would be leached from these materials are 2.14×10^{9}, 7.17×10^{11}, 2.00×10^{7}, and 6.97×10^{9} grams, respectively. The above figures show that the calculated leaching relationship overestimates the quantity of iron that could be leached from the wastes. Nearly two percent of the sulfate-sulfur could be leached from the waste in addition to more than 10 percent of the copper and more than 30 percent of the manganese. Despite the loss of metals and sulfate from the Type II waste rock and saprolite, there is no net loss from these materials since the metals and sulfate are returned to the stock-piled wastes in the form of precipitate.

2.2.2 In-Pit Model

Backfilling of the open pit will commence upon completion of the mining operations at the end of the third quarter of the sixth year of operation (period 6-3). The waste materials will be returned to the pit in this sequence: Type II waste materials at the bottom, followed in turn by Type I waste rock, saprolite, sandstone, till, and, topsoil. This sequence will be layered, and beginning with the saprolite layer, will approximate the original stratigraphic sequence of the site. The saprolite layer will be placed such that it ties in with the saprolite surrounding the pit and will be compressed to form a low permeability layer between the Type I and II materials and the overburden materials.

The Type II materials will be placed such that the lifts gently slope towards the narrow ends of the pit. This will facilitate the collection of pit inflow and precipitation, should these waters accumulate faster than the material is backfilled. Waters collected by the sump pumps installed at the narrow ends of the pit will be considered contact water and will be pumped to the wastewater treatment facility.

In addition, lime slurry will be added to the daily accumulation of Type II materials in sufficient quantity to raise the pH of the discharge water to at least 6.5 (see KMINE and KEIR for the calculations of the quantity of lime that will be required). The liming will limit the release of substances from the backfilled Type II wastes when these materials are saturated with the incoming waters.

During the backfilling of the Type II wastes, the slurried precipitate from the wastewater treatment facility will be added to these materials in the pit rather than added to the remaining stockpiled wastes. Since the pH of the pit water will be 6.5 or greater, pH sensitive components in the precipitate will be more stable in the pit than on the stockpile where the pHs will range from 3 to 4. This is important for the stability of the copper, iron and manganese compounds. It will have little or no effect upon the solubility of gypsum, the main source of soluble sulfate. The Type II liner system will be dismantled upon the completion of the backfilling of the Type II wastes. The sand blanket and stockpile basal support materials will then be added to the top of the backfilled Type II wastes.

A copy of Table No. 5-1 (KMINE) is included in Appendix A. This table lists the sequence of, and quantity of, the backfilled wastes as a function of mine bench level.

The porosities of the backfilled waste materials were estimated by increasing the original material volume by the swell factor, and then reducing by the compaction factor. This porosity multiplied by the volume of wastes estimates the pore volume that will be filled by the inflowing waters. The results of these calculations are presented in Table No. 2-3 along with the estimated time required to fill the physically created pore volumes.

TABLE NO. 2-3

Calculated Volumes and Times of Saturation of Backfilled Wastes During Remediation

Material	Volume (cu yds)	Porosity (%)	Pore Volume (L)	Cum. Volume (L)	Time to Fill (yrs)	Cum. Time (yrs)
WR II	1.96E+06	15	2.25E+08	2.25E+08	2.55	2.55
WRI	6.29E+05	15	7.21E+07	2.97E+08	1.42	3.97
SAP	4.84E+05	22	8.14E+07	3.79E+08	1.87	5.84
SS	4.22E+05	16	5.16E+07	4.30E+08	1.30	7.14
TILL	2.04E+05	17	9.48E+07	5.25E+08	2.67	9.81

Note: WR II = Type II Waste Rock and Sandstone
WR I = Type I Waste Rock
SAP = Type I Saprolite
SS = Sandstone
TILL = Volume of Till Beneath the Water Table

The rate at which water will saturate the backfilled wastes has been calculated by summing the yearly precipitative inputs (precipitation, runoff and infiltration) with the estimated pit inflow water derived from groundwater. It is assumed that backfilling the pit will be completed in 18 months. During the backfilling the pit will receive direct precipitation and runoff. Following the completion of the backfilling, the pit will continue to receive water from precipitation but it will be by infiltrative processes (see Appendix N, KMINE for precipitative data).

Based upon data presented by Prickett (1989), it was estimated that the groundwater level above the pit would be restored in approximately 10 years following the termination of mining. It was assumed that 75 percent of the groundwater pit inflow would occur in the first 20 percent of the pit inflow time and that the quantity of inflowing water would geometrically decrease with time during the inflow. In addition, it was assumed that the first pit inflow water would enter the pit at the rate equivalent to that which occurred during the end of the mining operation, i.e., an average value of 114 gpm. The quantities of precipitative and inflow waters entering the backfilled pit during the post mining recovery of groundwater are presented in Table No. 2-4. As seen in the table, the main source of water is from precipitative sources and that during the first year of recovery the pit inflow and precipitative inputs are nearly equal.

The in-pit chemical transport model traces the movement of the water which has been in contact with the Type II wastes and the dissolution of the soluble compounds within that waste. As previously stated, the concentration of copper, iron, manganese, and, sulfate within this contact water will be a function of the most soluble substances containing these parameters. In the Type II wastes, the solubilities of copper hydroxide, iron hydroxide

TABLE NO. 2-4

Post Mining Recovery of Groundwater

Year	Precipitative Inputs (L) Annual	Precipitative Inputs (L) Cumulative	Pit Inflow (L) Annual	Pit Inflow (L) Cumulative	Total (L) Cumulative
1	5.84E+07	5.84E+07	5.92E+07	5.92E+07	1.18E+08
2	5.32E+07	1.12E+08	2.96E+07	8.88E+07	2.01E+08
3	3.61E+07	1.57E+08	1.48E+07	1.04E+08	2.61E+08
4	3.61E+07	1.93E+08	7.40E+06	1.11E+08	3.04E+08
5	3.61E+07	2.29E+08	3.70E+06	1.15E+08	3.44E+08
6	3.61E+07	2.65E+08	1.85E+06	1.17E+08	3.82E+08
7	3.61E+07	3.02E+08	9.25E+05	1.17E+08	4.19E+08
8	3.61E+07	3.38E+08	4.63E+05	1.18E+08	4.56E+08
9	3.61E+07	3.74E+08	2.31E+05	1.18E+08	4.92E+08
10	3.61E+07	4.10E+08	1.16E+05	1.18E+08	5.28E+08

(and ferrihydrite), manganese hydroxide, and, gypsum will determine the concentrations of these parameters.

In order to calculate the concentration of a given parameter that will exist in water that is in equilibrium with the substance containing that parameter, it is necessary to multiply the solubility of the substance by the quotient of the molecular weight of the parameter of concern (e.g., sulfate) divided by the molecular weight of the substance containing that parameter (e.g., gypsum). The calculated concentrations of copper, iron, manganese, and, sulfate that will be maintained in the contact water are 22 ug/L, 320 ug/L, 736 ug/L, and 1,360 mg/L, respectively. These concentrations are derived from the most soluble substances containing the parameters of interest, the concentrations will remain at these levels until all of the substances containing them dissolves.

The layer of Type II waste is saturated from below with inflowing groundwater and from above by precipitative water. Once this layer is saturated the soluble substances will begin to dissolve thus developing the parameter concentrations discussed above. In the model equilibrium was assumed between the wastes and the water saturating or moving through the wastes. If equilibrium were not established, then the modeled parameter concentrations would be lower. The assumption that equilibrium will be established is, therefore, a conservative one.

As the Type II wastes become saturated, water flows into them, displacing contact water with elevated concentrations of metals and sulfate into the overlying formations. By the time that the preexisting groundwater levels are reestablished (calculated to be 9.81 years) a total of 1.18×10^8 liters of this contact water will have been transported into the Type I waste rock and into the lower 56 percent of the Type I saprolite. It was assumed that, since a piston flow model was used to determine chemical transport, that the contact water will displace the water that had been in the pores of these wastes without becoming diluted by, or mixing with, it.

Prickett (1989) determined that when groundwater levels have been reestablished, water will flow through the combined Type II wastes and Type I waste rock at an average rate of 1.4 gpm (2.79 x 10^6 liters/yr). Added to this 1.4 gpm flow will be 0.6 gpm (1.19 x 10^6 liters/yr) of water that will flow through the saprolite into these lower waste layers. A combined flow of 2.0 gpm (3.98 x 10^6 liters/yr) will leave the pit in the Precambrian rock at the western end through the river pillar. This flow will transport elevated groundwater concentrations from the Type II wastes, and from the Type I waste rock and lower saprolite, to the Flambeau River, west of the mine site.

The waste materials have capabilities to sorb some of the parameters released from the precipitate in the Type II wastes. The capacity for the sorption of specific parameters by a given material (in micrograms) can be calculated by multiplying the weight of the material (in grams) by the sorption capability (in ug/g). The sorption capabilities were derived from the results of the saturated leaching studies (see KEIR Table No. 3.5-23 and 3.5-26 for values).

The capability of the Type I waste rock and saprolite for the sorption of iron is 1.67 ug/g and 1.51 ug/g, respectively. The calculated sorption capacities of these materials for iron are 1.64 x 10^6 g and 1.04 x 10^6 g, respectively (it is interesting that the Type II wastes are also capable of sorbing iron). The capability of the Type I waste rock and saprolite for the sorption of manganese is the same, 0.17 ug/g. The calculated sorption capacities of these materials for manganese are 1.67 x 10^5 g and 1.17 x 10^5 g, respectively. Only the saprolite has a capability for the sorption of copper, which is 0.11 ug/g. The calculated sorption capacity of the saprolite for copper in 7.58 x 10^4 g. None of the waste materials that will come in contact with the water flowing out of the Type II zone in the bottom of the pit exhibits a capacity for the sorption of sulfate.

In calculating the concentration of copper, iron or manganese in water within one of the sorbing materials, the incoming concentration was reduced to the background level by the sorption of one of the metals by the waste material. The sorption process is considered to continue in operation until the sorption capacity of the waste is reached. There is no further attenuation of metal concentration until all of the soluble source substances are dissolved. The background concentrations of copper, iron, manganese, and sulfate are 13 ug/L, 220 ug/L, 350 ug/L, and, 9.9 mg/L, respectively (these are the mean concentrations for the shallow Precambrian wells presented in Table No. 3.6-12 in KEIR).

The output of the in-pit model is a time based series of parameter concentrations through the first few thousand years following the initiation of groundwater flow through the backfilled wastes. The in-pit pH will be controlled at 6.5 in perpetuity due to the liming. The output for sulfate, manganese, iron, and, copper is shown on Table No. 2-5. The calculations used to compute these concentrations are included in Appendix B.

2.2.3 Model Output Summary

The output of the in-pit model suggests that the concentrations of copper, iron, and manganese that are expected to occur in the water leaving the pit are nearly the same as the background concentrations of these metals. The predicted concentration of sulfate in the water leaving the pit will be approximately 140 times

TABLE NO. 2-5

Predicted Parameter Concentrations of Contact Groundwater Leaving the Backfilled Pit

Parameter	Concentration, mg/L	Years
Sulfate	1,360	0-8.42
	1,100	8.42-132
	832	132-2,850
	317	2,850-3,010
	9.9	3,010+
Manganese	0.550	0-3,920
	0.445	3,920-4,000
	0.350	4,000+
Iron	0.320	>4,000
Copper	0.014	>4,000

the background concentration. Even considering the overestimate of the materials leached from the stockpiled wastes, elevated concentrations of sulfate will exist in the water leaving the backfilled pit.

The concentrations of copper, iron, manganese, and, sulfate presented in this report are greater than those presented in the KEIR. These differences are the result of the pit inflow quantities being several times lower in Prickett (1989) than those reported in the KEIR. The reduction in flow results in less precipitate being produced and, therefore, the precipitate has less effect on the pH of the leachate in the stockpile. The pH of the leachate is the main factor governing the concentration of sulfate in the water leaving the backfilled pit since nearly all of the leached sulfate will become incorporated in the very soluble mineral gypsum.

The quantities of the metals leached from the wastes are also pH dependent but the metals form compounds that are not as soluble as gypsum. Of greater importance to the concentration of the metals--especially copper and manganese--in the water leaving the pit, is the fact that a lower pit inflow results in higher concentrations of metals in the waters treated in the wastewater treatment facility. This results in a change in the relative proportions of hydroxide and sulfides in the precipitates. Lower metal concentrations in the leachate favors the formation of greater quantities of sulfides, which are several orders of magnitude less soluble than the hydroxides for a given metal.

3.0 TRANSPORT CALCULATION

The cross-sectional flow model produced by Prickett (1989) for flow through reclaimed pit clearly demonstrates the downward nature of all the vertical hydraulic gradients through the saprolite layer overlying the waste rock. Under these conditions, all of the groundwater flowing through the Type II waste rock in the reclaimed pit will exit the pit through the Precambrian rock in the river pillar and flow directly into the bed of the Flambeau River.

Since this flow path is very short and occurs entirely within fractured crystalline rock, there will be little if any dispersion or retardation of the dissolved constituents in the groundwater. As described above, the dissolved constituents that will be added to the background crystalline groundwater by the Type II material in the pit will be copper, manganese, iron, and sulfate. Since there will be no dispersion, dilution, or retardation, in the river pillar, the concentrations of these constituents in the groundwater leaving the pit will be the same as the concentrations entering the river bed. As shown above in Section 2.2.2, these concentrations are:

Copper - 0.014 mg/L
Manganese - 0.522 mg/L
Iron - 0.32 mg/L
Sulfate - 1,360 mg/L

The metal concentrations are not statistically different from the background groundwater quality in the shallow bedrock as presented in the KEIR. In that document, the mean background concentration of copper is 0.013 mg/L, manganese is 0.35 mg/L, and iron is 0.22 mg/L. If, as is a common statistical practice, the standard deviation of the data is added to the mean to create a reasonable upper bound for the range in which the data may be said to routinely occur, the numbers for background copper, manganese, and iron are 0.031 mg/L, 0.54 mg/L, and 0.43 mg/L, respectively. Thus it can be seen that the predicted concentrations for these compounds in the groundwater emanating from the Type II waste rock in the reclaimed pit are well within the range for background norms at the site.

The background concentration of sulfate is 9.9 mg/L. With the standard deviation added to define the upper bound, it is 18.4 mg/L. This is statistically different from the predicted 1,360 mg/L of sulfate in the groundwater emanating from the Type II waste rock in the reclaimed pit.

Two of the same four parameters routinely occur in measurable concentrations in the Flambeau River water itself. According to the KEIR, the average river concentrations are:

Copper - <0.005 mg/L
Manganese - <0.05 mg/L
Iron - 0.40 mg/L
Sulfate - 10 mg/L

Thus the river has higher background concentrations of iron than does the groundwater. It has a sulfate concentration similar to the groundwater, and manganese and copper concentrations less than the groundwater.

4.0 POTENTIAL IMPACTS TO WATER QUALITY

At the Flambeau site there are, theoretically, two types of impacts which could result from altered groundwater quality. The first impact would be to the groundwater itself, while the second would be the potential effect of altered groundwater quality on the surface water quality in the Flambeau River.

As shown below, neither of these possibilities is viable.

4.1 Groundwater

The default groundwater standards in NR 182.075(1)(A)2a are the federally-defined MCLs (maximum contaminant levels), which are based on the national primary and secondary drinking water standards. Primary standards are defined for those compounds that can cause health-related problems in drinking water. Secondary standards are defined for those compounds that can cause only aesthetic problems (i.e., taste and odor) in drinking water.

None of the compounds for which primary standards have been defined will be found in measurable concentrations in the groundwater emanating from the Type II waste rock in the reclaimed pit.

Three of the compounds for which secondary standards have been defined--copper, manganese, and iron--will be found in measurable concentrations above the standards, but at concentrations which are also comparable to naturally occurring concentrations. In such cases, NR 182.075(1)(a)2.b. states:

> Where the baseline concentration of a substance subject to a state or national drinking water standard exceeds the MCL, set by state or national drinking water standards, the groundwater quality standard shall be the baseline concentration of that substance......

While sulfate at 1,360 mg/L, is above the background concentration of 9.9 mg/L, and above the standard of 250 mg/L, this is not a problem. Sulfate will not exceed the MCL beyond the Flambeau River, which is only 140 feet from the edge of the mine pit. In addition, since the river will serve as a very effective hydraulic boundary and the river pillar acts as a sink for groundwater, it is assured that the elevated sulfate concentrations will never be able to travel more than 140 feet from the reclaimed pit. Furthermore, since sulfate cannot travel more than 140 feet, and since the compliance boundary has been proposed at a distance of 1,200 feet, it will not be possible for sulfate exceedences to occur at the compliance boundary.

4.2 Surface Water

Not only do the four parameters pose no threat to the groundwater itself, they also do not threaten the Flambeau River in any way. To illustrate the lack of river impact, a calculation was made of the effect the groundwater will have upon the concentration of these substance in the Flambeau River.

According to the KEIR, the mean flow in the river is 1,855 cubic feet per second (cfs). According to Prickett (1989), the groundwater flow into the river from the waste rock zone in the reclaimed pit will be 2.0 gpm, or 0.0045 cfs. When these factors are applied, the incremental increase in river concentrations would be:

Copper - 0.000000034 mg/L
Manganese - 0.0000013 mg/L
Iron - 0.00000078 mg/L
Sulfate - 0.0033 mg/L

Clearly there is no potential adverse impact. The predicted increase in river concentrations would be so low that they would not even be detectable in the water by today's sophisticated analytical laboratory techniques. Since all the known potential adverse health and environmental impacts from these compounds occur well above the detection levels for the compounds, it must be concluded that the groundwater emanating from the Type II waste rock in the reclaimed pit will pose no threat to the Flambeau River.

5.0 REFERENCES

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APPENDIX A

Table No. 5-1 from the *Mining Permit Application for the Flambeau Project, Revised December 1989*

TABLE NO. 5-1 from KMINE

Bench	WR II (ktons)	WR I (ktons)	SAP (ktons)	SS (ktons)	TILL (ktons)	TOTAL (ktons)	Cum. Backfill (ktons)
900	34	0	0	0	0	34	34
910	52	0	0	0	0	52	86
920	69	0	0	0	0	69	155
930	85	0	0	0	0	85	240
940	108	0	0	0	0	108	348
950	128	0	0	0	0	128	476
960	220	0	0	0	0	220	696
970	243	0	0	0	0	243	939
980	265	0	0	0	0	265	1,204
990	297	0	0	0	0	297	1,501
1000	314	0	0	0	0	314	1,815
1010	335	0	0	0	0	335	2,150
1020	445	0	0	0	0	445	2,595
1030	414	0	0	0	0	414	3,009
1040	113	245	0	70	0	428	3,437
1050	0	477	0	0	0	477	3,914
1060	0	357	139	0	0	496	4,410
1070	0	0	473	0	0	473	4,883
1080	0	0	147	469	0	616	5,499
1090	0	0	0	290	295	585	6,084
1100	0	0	0	0	516	516	6,600
1110	0	0	0	0	482	482	7,082
1120	0	0	0	0	396	396	7,478
1130	0	0	0	0	288	288	7,766
1140	0	0	0	0	2	2	7,768
TOTALS:	3,122	1,079	759	829	1,979	7,768	

APPENDIX B

In-Pit Model Calculations

1. INTRODUCTION

a. The model calculated the transport of sulfate, manganese, iron, and copper from the saprolite (SAP), Type I waste rock (WRI), and Type II waste materials (WRII). The latter include both waste rock and saprolite.

b. The concentration of sulfate, manganese, iron, and copper was considered to be a function of the most soluble solid phase that contained each parameter. These were gypsum (hydrous calcium sulfate), manganese, iron hydroxide (ferrihydrite)), and copper hydroxide, respectively.

c. A piston flow of water, and consequent transport of these materials, was modeled. This assumes that water containing background concentrations of the parameters replaces a certain volume of water within the backfilled wastes and that an equal volume of water containing dissolution products of the soluble substance leaves the wastes.

  - 0.6 gpm, or 1.19×10^6 L/yr, enters the wastes stored below the saprolite layer and combines with the 1.4 gpm, or 2.79×10^6 L/yr of water flowing into these wastes from the eastern end of the pit. A total of 2.0 gpm, or 3.98×10^6 L/yr, flows out of these wastes through the western end of the pit, known as the river pillar.

d. During the recharge of the backfilled wastes, groundwater flows into the wastes from below and precipitation and runoff water into the wastes from above.

- The 1.18×10^8 L of groundwater that will enter the base of the WRII will result in an upward displacement of 1.18×10^8 L of water into the WRI and into the lower 56 percent of the SAP.

- This displacement will decrease the total quantity of soluble materials with the lower portion of the WRI.

- It was assumed that groundwater flow through the stockpiled wastes would not commence until the former groundwater levels were reestablished. Lateral groundwater flow through the wastes would begin at that time. The three waste layers--SAP, WRI, and WRII--would respond chemically as five separate layers. These layers are: 1) the upper 44 percent of the SAP layer containing 3.55×10^7 L pore volume which would be filled with water containing only background concentration of chemicals; 2) the lower 56 percent of the SAP layer containing 4.59×10^7 L of pore volume which would be filled with the water displaced from the WRII layer; 3) the WRI layer containing 7.21×10^7 L pore volume which would also be filled with water displaced from the WRII layer; 4) the upper 47 percent of the WRII layer containing 1.07×10^8 L of pore volume which would be filled with water in equilibrium with the soluble compounds; and 5) the lower 53 percent of the WRII layer containing 1.18×10^8 L of pore volume which would be filled with water in equilibrium with the soluble compounds but differing from the upper portion of the WRII in that the quantity of soluble compounds would have been depleted by the quantity of dissolved minerals that were displaced into the WRI and SAP layers.

- These five layers are referred to as SAPA, SAPB, WRI, WRIIA, and WRIIB, respectively.

- The 0.6 gpm flowing through the two SAP layers would displace 3.55 X 10^7 L/yr and 4.59 X 10^7 L/yr from the SAPA and SAPB, respectively.

- The 1.4 gpm flowing through the WRI and WRII layers would displace 6.76 X 10^5, 1.00 X 10^6, and 1.11 X 10^6 L/yr from the WRI, WRIIA, and WRIIB, respectively.

e. It was assumed that equilibrium would be established instantly between the inflowing groundwater and the soluble compounds. Also, it was assumed that there would be no suppression of the solubilities of these compounds due to common ion effects.

f. Some of the layers sorb some of the dissolved chemicals. Copper is sorbed by the SAP layer, manganese by the SAP and WRI layers, and iron by the SAP, WRI, and WRII layers. Sulfate is not sorbed by any of the layers.

- It was assumed that the sorption reactions occur instantly.

- No desorption reactions were used in the model.

- It was assumed that the measured concentrations of these chemicals in the shallow Precambrian wells represents concentrations that are in equilibrium with these crystalline rocks. The reduction in concentrations of a given chemical due to sorption processes is the initial concentration minus the background concentration.

2. SULFATE

a. A total of 8.60×10^{12} mg of sulfate in the form of gypsum will be contained within the WRII layer.

b. The solubility of gypsum in pure water is 2,400 mg/L. Sulfate derived from the dissolution of gypsum will have a concentration of $100/176 \times 2{,}400 = 1{,}360$ mg/L.

c. The background concentration of sulfate in the shallow Precambrian wells is 9.9 mg/L.

d. The quantity of sulfate contained within the pore water of each sublayer at the time lateral groundwater flow commences will be:

<u>SAPA</u>	3.5×10^{7} L $\times$ 9.9 mg/L = 3.52×10^{8} mg
<u>SAPB</u>	4.59×10^{7} L $\times$ 1,360 mg/L = 6.24×10^{10} mg
<u>WRI</u>	7.21×10^{7} L $\times$ 1,360 mg/L = 9.81×10^{10} mg
<u>WRII</u>	2.25×10^{8} L $\times$ 1,360 mg/L = 3.06×10^{11} mg

e. The amount of sulfate displaced from WRIIB to fill the pores in WRI and SAPB is:

$$6.24 \times 10^{10} \text{ mg} + 9.81 \times 10^{10} \text{ mg} = 1.61 \times 10^{11} \text{ mg}$$

Therefore, the quantity of sulfate contained in WRIIA and WRIIB is:

<u>WRIIA</u>	6.97×10^{12} mg $\times$ 0.47 = 3.32×10^{12} mg
<u>WRIIB</u>	$(6.97 \times 10^{12}$ mg $\times$ 0.53) $- 1.61 \times 10^{11}$ = 3.49×10^{12} mg

f. The rate of removal of sulfate from each layer is:

<u>SAPA</u>	5.21×10^5 L/yr X 9.9 mg/L = 5.16×10^6 mg/yr
<u>SAPB</u>	6.72×10^5 L/yr X 1,360 mg/L = 5.16×10^6 mg/yr
<u>WRI</u>	6.76×10^5 L/yr X 1,360 mg/L = 5.16×10^6 mg/yr
<u>WRIIA</u>	1.00×10^6 L/yr X 1,360 mg/L = 5.16×10^6 mg/yr
<u>WRIIB</u>	1.11×10^6 L/yr X 1,360 mg/L = 5.16×10^6 mg/yr

g. The length of time required to dissolve and remove all of the sulfate contained in a given sublayer is equal to the quantity of sulfate contained within that sublayer divided by the rate of removal (values listed in 2.d and 2.e divided by those in 2.f). The calculated times are:

<u>SAPB</u>	8.42 years
<u>WRI</u>	132 years
<u>WRIIA</u>	3,010 years
<u>WRIIB</u>	2,850 years

h. The concentrations of sulfate in the groundwater leaving the pit through the river pillar is a function of the time required to move the sulfate from each layer (2.g, above), the concentration of sulfate in equilibrium with gypsum, and the background concentration of sulfate. The time based concentrations are:

0-8.42 years: 1,360 mg/L
8.42-132 years: 1,100 mg/l
132-2,850 years: 832 mg/l
2,850-3,010 years: 317 mg/L
3,010+ years: 9.9 mg/L

3. MANGANESE

a. A total of 2.47 X 10^{10} mg of manganese in the form of manganese hydroxide and manganese sulfide will be contained within the WRII layer.

b. Twenty five percent of the total manganese will be the soluble compound, manganese hydroxide. The solubility of the hydroxide is 1.2 mg/L, of which 0.725 mg/L is manganese (1.2 X [55/91]).

c. The background concentration of manganese is 350 mg/L.

d. The quantity of manganese contained within the pore water in each sublayer at the time lateral groundwater flow commences will be (no sorption considered):

<u>SAPA</u>	3.55 X 10^7 L X 0.350 mg/L = 1.24 X 10^7 mg
<u>SAPB</u>	4.59 X 10^7 L X 0.725 mg/L = 3.33 X 10^7 mg
<u>WRI</u>	7.21 X 10^7 L X 0.725 mg/L = 5.23 X 10^7 mg
<u>WRII</u>	2.25 X 10^6 L X 0.725 mg/L = 1.63 X 10^8 mg

The SAPB layer has a sorption capacity of 6.55 X 10^7 mg for manganese (1.17 X 10^8 mg X 0.56). Layer WRI has a sorption capacity of 1.67 X 10^8 mg for manganese. There is more than enough sorption capacity in each layer to sorb all the manganese displaced into these layers from the WRIIB displacement. Therefore, the manganese concentrations in layers SAPB and WRI will be 0.350 mg/L, the background concentration.

e. The amount of soluble manganese displaced from WRIIB to fill the pores in WRI and SAPB is:

$$5.23 \text{ X } 10^7 \text{ mg} + 3.33 \text{ X } 10^7 \text{ mg} = 8.59 \text{ X } 10^7 \text{ mg}$$

Therefore, the quantity of soluble manganese contained in WRIIA and WRIIB is:

<u>WRIIA</u> $(2.00 \text{ X } 10^{10} \text{ mg X } 0.25) \text{ X } 0.47 = 2.35 \text{ X } 10^9 \text{ mg}$

<u>WRIIB</u> $([2.00 \text{ X } 10^{10} \text{ mg X } 0.25] \text{ X } 0.53) - 8.56 \text{ X } 10^7 \text{ mg}$
$= 2.56 \text{ X } 10^9 \text{ mg}$

f. The rate of removal of soluble manganese from each layer is:

<u>SAPA</u>	$5.21 \text{ X } 10^5 \text{ L/yr X } 0.350 \text{ mg/L} = 1.82 \text{ X } 10^5 \text{ mg/yr}$
<u>SAPB</u>	$6.72 \text{ X } 10^5 \text{ L/yr X } 0.350 \text{ mg/L} = 1.35 \text{ X } 10^5 \text{ mg/yr}$
<u>WRI</u>	$6.76 \text{ X } 10^5 \text{ L/yr X } 0.350 \text{ mg/L} = 2.37 \text{ X } 10^5 \text{ mg/yr}$
<u>WRIIA</u>	$1.00 \text{ X } 10^6 \text{ L/yr X } 0.725 \text{ mg/L} = 7.25 \text{ X } 10^5 \text{ mg/yr}$
<u>WRIIB</u>	$1.11 \text{ X } 10^6 \text{ L/yr X } 0.725 \text{ mg/L} = 8.05 \text{ X } 10^5 \text{ mg/yr}$

g. Only the soluble manganese in layers WRIIA and WRIIB will contribute to the concentration of manganese above background in the groundwater leaving the pit. The time required to dissolve and remove all the manganese in these two sublayers can be calculated by dividing the quantity of soluble manganese in each layer by the removal rate (values in 3.e divided by those in 3.f). The calculated times are:

<u>WRIIA</u>: 4,000 years
<u>WRIIB</u>: 3,920 years

h. The concentration of soluble manganese in the groundwater leaving the pit through the river pillar is a function of the time required to remove the manganese from each layer (3.g above), the concentration of manganese in equilibrium with manganese hydroxide, and the background concentration of manganese. The time based concentrations are:

0-3,920 years: 550 ug/L
3,920-4,000 years: 445 ug/L
4,000+ years: 350 ug/l

4. IRON

a. A total of 8.84×10^{11} mg of iron in the form of iron hydroxide and the mineral ferrihydrite (a hydrous iron oxide) will be contained within the WRII layer.

b. The solubility of these compounds is limited since they are stable an sparingly soluble materials. A concentration of 320 ug/L of iron is supported in solution by these compounds. This is approximately the solubility of ferric iron under these conditions.

c. The background concentration of iron in the shallow Precambrian wells is 220 ug/L.

d. All of the modeled waste materials sorb iron. It is assumed that the equilibrium concentration that the water will maintain is 220 ug/L.

e. The rate of removal of iron from these waters is:

$$3.98 \times 10^6 \text{ L/yr} \times 0.320 \text{ mg/L} = 1.27 \times 10^6 \text{ mg/yr}$$

f. The time required to reduce the 320 ug/L to the background concentration of 220 ug/L is:

$$8.84 \times 10^{11} \text{ mg} / 1.27 \times 10^{6} \text{ mg/yr} = 696{,}000 \text{ years}$$

The calculated time suggests that approximately 700,000 years will be required to reduce the initial concentration supported by these sparingly soluble materials.

5. COPPER

a. A total of 2.64×10^{12} mg of copper, mainly in the form of copper hydroxide, will be contained within the WRII wastes.

b. The solubility of copper hydroxide is 22 ug/L. The concentration of copper in equilibrium with copper hydroxide in pure water is 14 ug/L ((64/100) X 22). Copper hydroxide is less soluble than iron hydroxide at near-neutral pH conditions.

c. The background concentration of copper in the shallow Precambrian wells is 13 ug/L.

d. Since there is no statistical difference between the background concentration of copper and the copper supported in solution by copper hydroxide, there is little sense in modeling the changes in copper.

e. For the sake of completeness, the rate of removal of copper from the wastes, ignoring sorption, is:

$$3.98 \times 10^{6} \text{ L/yr} \times 0.014 \text{ mg/L} = 5.57 \times 10^{7} \text{ yrs}$$

f. The time required to reduce the 14 ug/L to the background concentration of 13 ug/L is:

$$2.64 \times 10^{12} \text{ mg} / 5.57 \times 10^{4} \text{ mg/yr} = 4.74 \times 10^{7} \text{ yrs}$$

The calculated time suggests that approximately 47 million years will be required for the complete removal of the rather insoluble copper hydroxide.

APPENDIX M

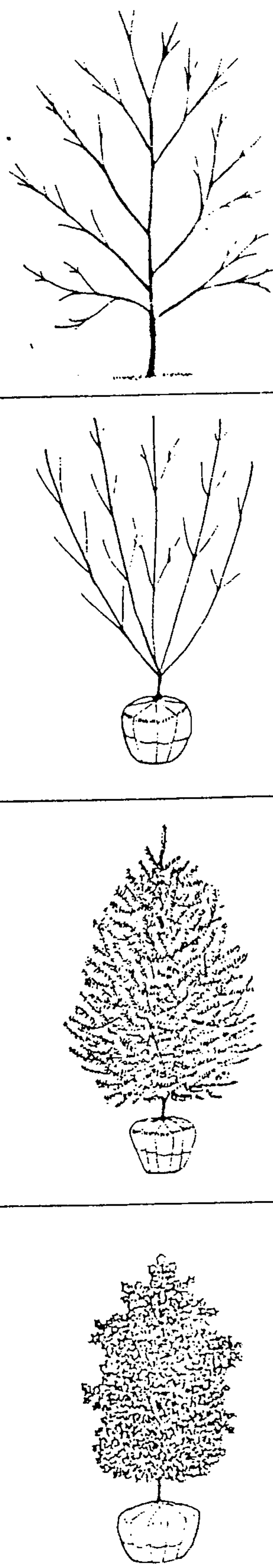
Reference Standards Applicable to Specie Selection, Seedbed Preparation, Planting Methods, and Mulching and Fertilizing Methods

Section 2480 Landscaping - Turf Establishment, and

Section 2490 Landscaping - Trees, Plants and Ground Cover

ANSI Z60.1-1973

Z60.1-1973



AMERICAN STANDARD FOR NURSERY STOCK

American Association of Nurserymen
230 Southern Building, Washington, D.C. 20005

FOREWORD

One of the early activities of the American Association of Nurserymen, Inc. was the development of a standardized system of sizing and describing plants to facilitate the trade in nursery stock. Since 1921 the Association has maintained an active committee on standards. Its first edition of "Horticultural Standards" was published in 1923. From time to time, these standards were revised and expanded to meet the needs of the industry.

After World War II the Association elected to make the standards a national standard by adhering to the standards procedures of the American Standards Association. The first edition published under the procedures of the Americsn Standards Association (forerunner of the current American National Standards Institute) was published on June 22, 1949.

The revisions included in the 1973 edition were developed by the Association's Horticultural Standards Committee since January 1969. The proposed revisions were submitted to interested national and regional societies, associations and governmental agencies for their review and endorsement.

STANDARDIZED PLANT NAMES

The nomenclature used in this issue of "American Standard for Nursery Stock" conforms to that of Standardized Plant Names, Second Edition, American Joint Committee on Horticultural Nomenclature, 1942. Publisher J. Horace McFarland Company, Harrisburg, Pennsylvania.

HORTICULTURAL STANDARDS COMMITTEE

Ralph Shugert, Chairman, Spring Hill Nurseries Company, Tipp City, Ohio
Larry Bachman, Bachman's, Inc., Minneapolis, Minnesota
Edward B. Ballard, Annandale, Virginia (Representing American Society of Landscape Architects)
Lester Begick, Bay City, Michigan (Representing National Landscape Association)
Bruce A. Briggs, Briggs Nursery, Olympia, Washington
Jack Brownell, Rhode Island Nurseries, Inc., Newport, Rhode Island
George Cultra, Morning Star Nursery, Inc., Rives, Tennessee
Robert Denney, Stark Bro's Nurseries & Orchards Co., Louisiana, Missouri
Homer Greenwood, Mount Arbor Nurseries, Shenandoah, Iowa
William Kreutzfeld, D. Hill Nursery Company, Dundee, Illinois
Michael V. Michael, Michael's Nursery, Boynton Beach, Florida
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William G. Thornton, Cincinnati, Ohio (Representing Associated Landscape Contractors of America)
William Tomlinson, Select Nurseries, Inc., Brea, California
Martin W. Usrey, Monrovia Nursery Company, Azusa, California
Dale E. Wild, The Sarcoxie Nurseries, Sarcoxie, Missouri
Hewitt Wilson, C.E. Wilson Nurseries, Inc., Jacksonville, Texas
Phillip Worth, Kankakee Nursery Company, Aroma Park, Illinois

American Association of Nurserymen, Inc.
230 Southern Building
Washington, D.C. 20005

TABLE OF CONTENTS

1 DECIDUOUS SHADE & FLOWERING TREES

1.1 GENERAL SPECIFICATIONS

1.1.1 CALIPER AND HEIGHT MEASUREMENT

In size grading B&B trees, caliper shall take precedence over height.

In size grading bare root trees, height shall take precedence to 8 ft., thereafter caliper takes precedence.

Caliper of the trunk shall be taken 6 inches above the ground level up to and including 4 inch caliper size and 12 inches above the ground level for larger sizes.

Where a minimum and maximum size, i.e. size range, is specified, the average of the lot should approximate the midpoint of the specified size range.

1.1.2 HEIGHT OF BRANCHING—STREET TREES

Unless otherwise specified trees are to be suitable for planting as street trees and are to be free of branches to a point about 50% of their height. Height of branching should bear a relationship to the size and kind of tree also so that the crown of the tree will be in good balance with the trunk as the tree grows.

Examples:

Acer platanoides, 2 to 2½ in. cal., 12 to 14 ft., branched 6 to 7 ft.

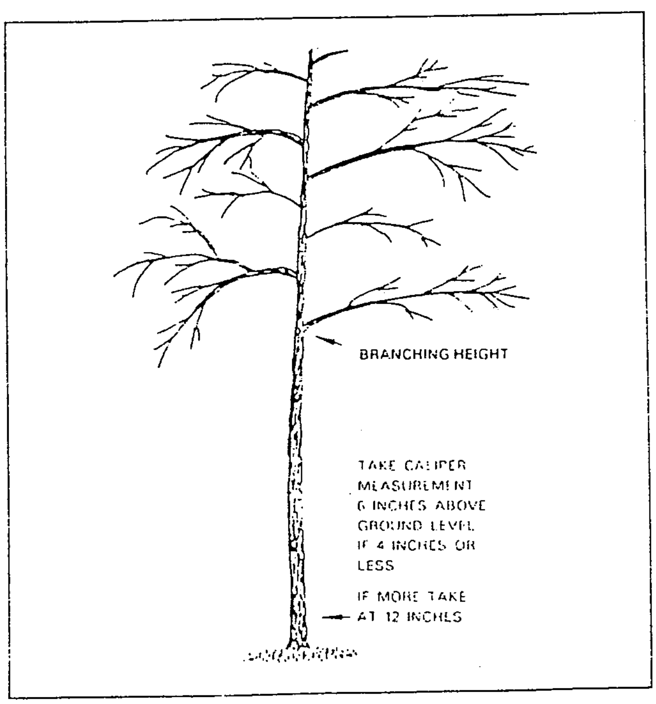
Quercus borealis 'Maxima' 3½ to 4 in. cal., 14 to 16 ft., branched 7 to 9 ft.

Trees with ascending branches (example — Ulmus americana and Tilia tomentosa) may be branched one foot or more below the standard height and still provide proper clearance which is the purpose of this specification.

1.1.3 HEIGHT RELATIONSHIP TO CALIPER BY TYPES

It is recognized that climatic conditions in different sections of the country produce trees of different caliper-height proportions. Trees from one region of the country may have less caliper in proportion to height while trees from another section may have greater caliper in proportion to height than shown in the following table.

The table in Type 1 shows the average height range and also maximum heights permitted. (See 1.1.3.1)



1.1.3.1 Type 1. Shade Trees

The height relationship to caliper will for most standard shade trees be as follows:

Caliper	Average Height Range	Maximum Heights
½ to ¾ in.	5 to 6 ft.	8 ft.
¾ to 1 in.	6 to 8 ft.	10 ft.
1 to 1¼ in.	8 to 10 ft.	11 ft.
1¼ to 1½ in.	8 to 10 ft.	12 ft.
1½ to 1¾ in.	10 to 12 ft.	14 ft.
1¾ to 2 in.	10 to 12 ft.	14 ft.
2 to 2½ in.	12 to 14 ft.	16 ft.
2½ to 3 in.	12 to 14 ft.	16 ft.
3 to 3½ in.	14 to 16 ft.	18 ft.
3½ to 4 in.	14 to 16 ft.	18 ft.
4 to 5 in.	16 to 18 ft.	22 ft.
5 to 6 in.	18 ft. and up	26 ft.

Sizes under one inch may be calipered if desired.

Examples:

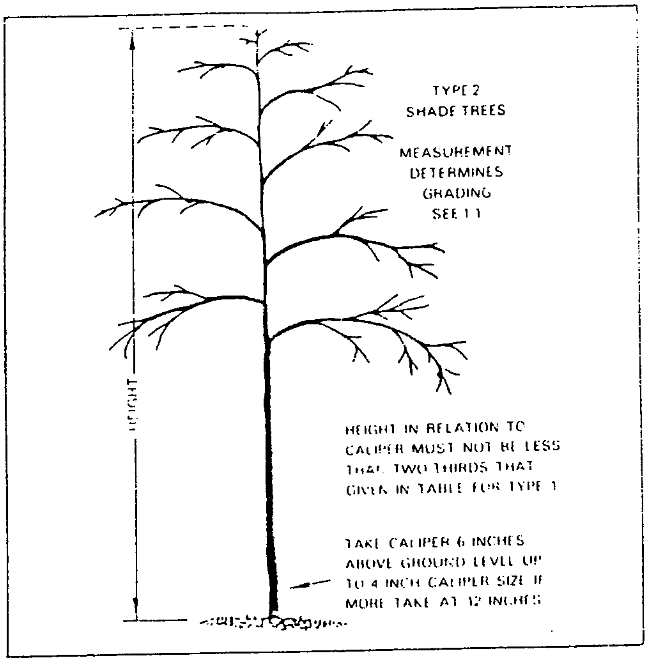
Acer rubrum, saccharinum
Betula
Fraxinus americana, pennsylvanica
Ginkgo
Gleditsia
Liriodendron
Platanus
Populus
Quercus borealis, macrocarpa, palustris, phellos
Salix
Tilia americana
Ulmus americana

1.1.3.2 Type 2. Shade Trees

Trees of slower growth which will not usually attain the height measurement in relation to caliper as in Type 1. The height should, however, be not less than two-thirds the height relationship given for Type 1. (See 1.1.3.1)

Examples:

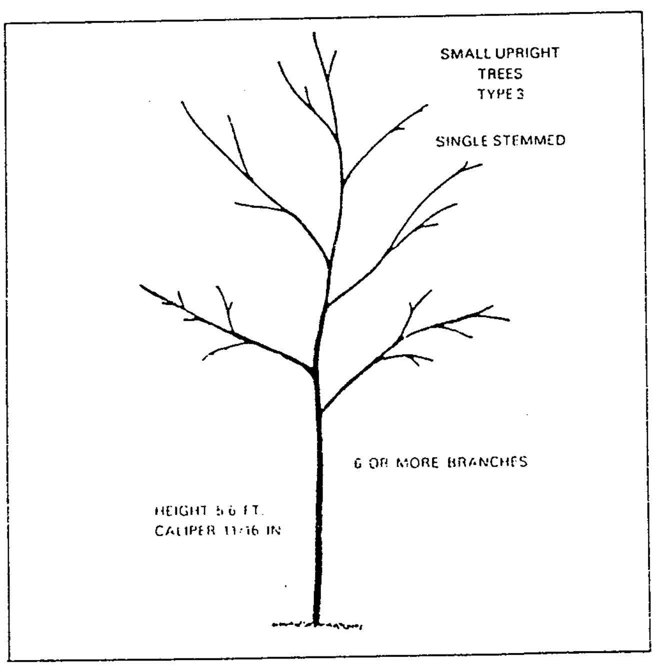
Aesculus
Celtis
Cladrastis lutea
Fagus sylvatica
Koelreuteria
Laburnum
Liquidambar
Nyssa
Quercus alba
Sorbus
Tilia cordata, euchlora



1.1.3.3 Type 3. Small Upright Trees

This is a broad group including small upright trees which may be grown as a clump or shrub. Height shall be the governing measurement. For single stem plants, the minimum relationship of caliper and branching will usually be as follows:

2 to 3 ft., 5/16 in. caliper, 3 or more branches
3 to 4 ft., 7/16 in. caliper, 4 or more branches
4 to 5 ft., 9/16 in. caliper, 5 or more branches
5 to 6 ft., 11/16 in. caliper, 6 or more branches
6 to 8 ft., 7/8 in. caliper, 7 or more branches



Examples:

Acer campestre, circinatum
Cercis
Crataegus
Halesia
Malus (most crabapples)
Prunus cerasifera 'Thundercloud'
Prunus serrulata, subhirtella
Styrax
Syringa amurensis 'Japonica'

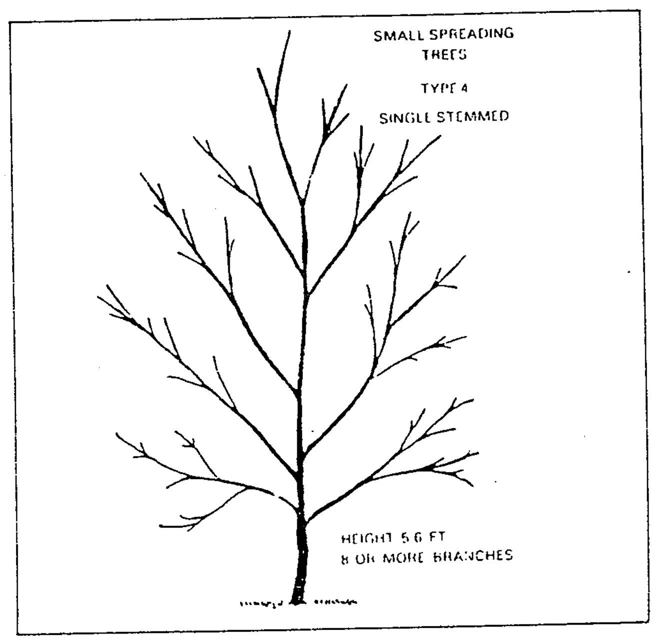
1.1.3.4 Type 4. Small Spreading Trees

This is a broad group including small spreading trees of dwarf habit of growth and certain large shrubs grown in tree or multi-stemmed form. Height shall be the governing measurement. For single stem plants, the minimum branching will be as follows:

2-3 ft. 4 or more branches
3-4 ft. 5 or more branches
4-5 ft. 7 or more branches
5-6 ft. 8 or more branches
6-8 ft. 8 or more branches

Examples:

Acer palmatum, griseum
Cornus
Lagerstromia indica
Magnolia, soulangeana, stellata
Malus sargentii
Viburnum prunifolium



1.1.4 DECIDUOUS TREES FOR OTHER USES

Trees for special uses should be branched or pruned naturally according to type. Where a form of growth is desired which is not in accordance with a natural growth habit, this form should be so specified.

Examples:

- **Bush form** — trees which start to branch close to the ground in the manner of a shrub.
- **Clumps** — trees with two or more main stems starting from the ground with the number of stems to be specified.
- **Cut back or Sheared**—trees that have been pruned back so as to multiply the branching structure and to develop a more formal effect.

Topiary—trees sheared or trimmed closely in a formal geometric pattern.

1.2 BARE ROOT SPECIFICATIONS

1.2.1 NURSERY GROWN—SPREAD OF ROOTS

All bare root trees shall have a well branched root system characteristic of the species. The following table represents the approved minimum root spread for nursery grown shade trees.

Caliper	Average Height Range	Minimum Root Spread
½ to ¾ in.	5 to 6 ft.	12 in.
¾ to 1 in.	6 to 8 ft.	16 in.
1 to 1¼ in.	8 to 10 ft.	18 in.
1¼ to 1½ in.	8 to 10 ft.	20 in.
1½ to 1¾ in.	10 to 12 ft.	22 in.
1¾ to 2 in.	10 to 12 ft.	24 in.
2 to 2½ in.	12 to 14 ft.	28 in.
2½ to 3 in.	12 to 14 ft.	32 in.
3 to 3½ in.	14 to 16 ft.	38 in.

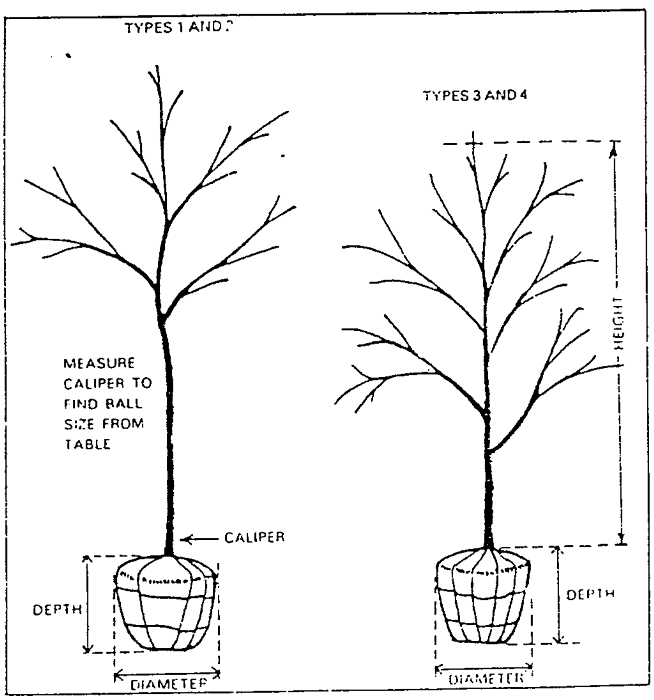
1.2.2 COLLECTED—SPREAD OF ROOTS

Trees collected from native stands or established plantings must be so designated. The spread of roots, bare root trees, shall be ⅓ greater than the spread of roots, bare root nursery grown, as tabulated above.

Trees collected from wild or native stands may be considered nursery grown when they have been successfully re-established in the nursery row and grown under regular nursery cultural practices for a minimum of two growing seasons and have attained adequate root and top growth to indicate full recovery from transplanting into the nursery row.

1.3 BALLING AND BURLAPPING SPECIFICATIONS

Ball sizes should always be of a diameter and depth to encompass enough fibrous and feeding root system necessary for the full recovery of the plant.



1.3.1 NURSERY GROWN

The following table represents the recommended minimum sizes of balls for trees which are being grown in the nursery under favorable growing conditions and which have received the proper cultural treatment to develop a well branched root system.

These specifications are for plants dug with the ball of earth in which they are growing.

Shade Trees Types 1 and 2		Trees Types 3 and 4	
Caliper	Minimum Diameter Ball	Height	Minimum Diameter Ball
Inches	Inches	Feet	Inches
½-¾	12		
¾-1	14	2-3	10
1-1¼	16	3-4	12
1¼-1½	18	4-5	14
1½-1¾	20	5-6	16
1¾-2	22	6-7	18
2-2½	24	7-8	20
2½-3	28	8-9	22
3-3½	32	9-10	24
3½-4	38	10-12	26
4-4½	42		
4½-5	48		
5-5½	54		

It is recognized that plants having a coarse or wide-spreading root system because of natural habit of growth, soil condition, infrequent transplanting practice, or that are moved out of season, would require a size of ball in excess of the recommended sizes.

1.3.2 COLLECTED

It is generally recognized that plants growing in their native state will sustain a much more severe shock when transplanted than the same kinds of plants when nursery grown. If collected material is moved, considerably larger ball than that recommended for transplanted nursery stock is required, because of the unrestricted root development and the varying conditions of soil in which such material is found.

The minimum ball sizes shall be equal to those specified in 1.3.1 for the next larger size nursery grown stock.

Trees collected from wild or native stands may be considered nursery grown when they have been successfully re-established in the nursery row and grown under regular nursery cultural practices for a minimum of two growing seasons and have attained adequate root and top growth to indicate full recovery from transplanting into the nursery row.

1.3.3 PLANTATION GROWN STOCK

Plants which have been systematically planted in fertile, friable soil which is relatively free of stones and foreign matter, but where there has been a minimum of after-care.

The minimum ball sizes shall be equal to those specified in 1.3.1 for the next larger size nursery grown stock.

1.3.4 BALL DEPTHS

Under certain soil and regional conditions, plants have root systems of proportionately less depth and greater diameter. These require a more shallow but wider ball to properly encompass the roots. Conversely in other soils and in certain regions roots develop greater depth and less spread, requiring an exceptionally deep ball which may be smaller in diameter and greater in depth than the size recommended.

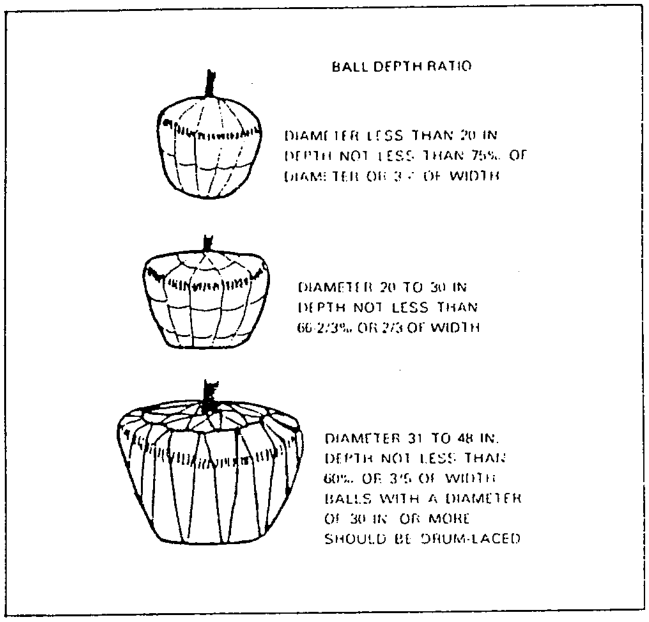
For the greater part of the country ball depths will carry the following ratios:

Balls with diameters less than 20 inches — Depth not less than 75% of diameter.

Balls with diameters of 20 inches to 30 inches incl. — Depth not less than 66-2/3% of diameter.

Balls with diameters of 30 inches to 48 inches incl. — Depth not less than 60% of diameter.

Balls with diameters over 48 inches will have the depth scaled down proportionately.



1.4 CONTAINER GROWN SPECIFICATIONS

All container grown trees shall be healthy, vigorous, well-rooted and established in the container in which they are sold. They shall have tops which are of good quality and are in a healthy growing condition.

An established container grown tree shall be a tree transplanted into a container and grown in that container sufficiently long for the new fibrous roots to have developed so that the root mass will retain its shape and hold together when removed from the container.

The container shall be sufficiently rigid to hold the ball shape protecting the root mass during shipping.

Dwarf and light growing varieties may be 1 or 2 sizes smaller than standard for a given size container.

The following table gives tree sizes and acceptable container sizes:

Tree Height	Container Size
12 to 18 in. 18 to 24 in. 2 to 3 ft. 3 to 4 ft.	1 gal. (trade designation) Minimum of 5½ inches across top and height of 6 inches or equivalent volume
2 to 3 ft. 3 to 4 ft. 4 to 5 ft.	2 gal. (trade designation) Minimum of 7 inches across top and height of 7½ inches or equivalent volume
4 to 5 ft. 5 to 6 ft. 6 to 8 ft.	5 gal., egg can or square can (trade designation) Minimum of 9 inches across top and height of 10 inches or equivalent volume

1.5 BALLED AND POTTED

Balled and potted plants are field-grown nursery plants, dug with a ball of earth still intact in which they are growing, and in lieu of burlapping, are placed in a container to retain the ball unbroken.

Ball sizes shall always be of a diameter and depth to encompass enough fibrous and feeding root system necessary for the full recovery of the plant.

The minimum ball size specification for "balled and potted" plants shall be the same as for "balled and burlapped" plants. (See 1.3.1)

2 DECIDUOUS SHRUBS

2.1 GENERAL SPECIFICATIONS

2.1.1 HEIGHT MEASUREMENT

2.1.1.1 Dwarf and Semi-dwarf Shrubs
State height in inches up to 24 inches, over 24 state in feet. Size grade in 3 inch series to 18 inches, six inches 18-24 inches, and over 24 inches in ½ foot series. Examples: 12-15 in.; 15-18 in.; 18-24 in.; 2-2½ ft.; 2½-3 ft.

2.1.1.2 Strong Growing Shrubs
Grade in 6-inch series up to 24 inches; example: 12-18 in.; over 24 inches by single feet up to 6 feet; then in double feet above 6 feet; example: 8-10 ft.

2.1.2 QUALITY DEFINITIONS

If a plant is well grown with single stem, well shaped and bushy and has sufficient well spaced side branches to give it weight and good bud qualities, it should be an acceptable plant.

A cane shall be considered a primary stem which starts from the ground or close to the ground at a point not higher than one-fourth the height of the plant.

2.1.3 GRADING TOLERANCE

The growing of plant material cannot be rigidly standardized because of varying conditions of growth and methods of handling preferred or necessitated by climate, soil, and other conditions beyond the control of the grower. Judgment should therefore be exercised and allowances made in the above definitions to agree with those which are recognized by the trade as typical of acceptable plants in that region.

2.1.4 RECOMMENDED GRADES

Lots or groups of plants of a given grade should have an approximate average height as in the following examples:

Grade of Plant	18-24 in.	2-3 ft.	3-4 ft.	4-5 ft.
Approximate Average of lot	21 in.	2½ ft.	3½ ft.	4½ ft.

The recommended grades apply to the height of plants grown under average soil and climatic conditions in nursery beds and fields, which have been transplanted, root pruned and trimmed according to regular nursery practice. Judgment must be exercised in interpreting and adapting these general classifications to any particular species or variety, and consideration given to the normal growth habit or other conditions peculiar to the region. (For container grown shrubs, see 2.4)

2.1.5 TYPES OF SHRUBS

2.1.5.1 Type 0 — Shrubs Having a Tendency Not to Mature All Top Growth
It is an accepted nursery trade practice to prune the top growth of these shrubs back to live wood.

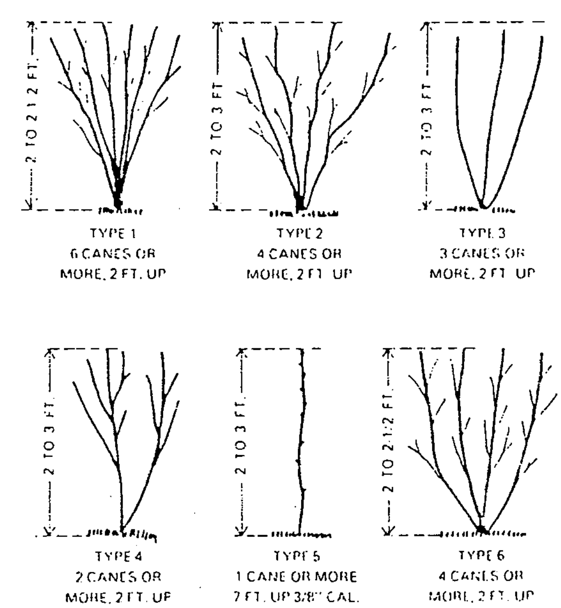
2.1.5.1.1 Type 0-1
6-9 in. shrubs should have no less than 2 canes, 6 in. and up of live top; 9 in. and up shrubs should have no less than 3 canes, 9 in. and up of live top.
Example: Hydrangea macrophylla

2.1.5.1.2 Type 0-2
9-12 in. shrubs should have no less than 2 canes, 9 in. and up of live top.
Examples: Caryopteris, Hypericum (shrubby types)

2.1.5.1.3 Type 0-3
12-18 in. shrubs should have not less than 2 canes, 12 in. and up of live top.
18 in. & up shrubs should have not less than 3 canes, 18 in. and up of live top.
Examples: Hydrangea arborsecens, Buddleia, Vitex

2.1.5.2 Type 1 — Shrubs: Dwarf and Semi-Dwarf
12-15 in. shrubs should have not less than 4 canes, 12 in. and up.
15-18 in. shrubs should have not less than 4 canes, 15 in. and up.
18-24 in. shrubs should have not less than 5 canes, 18 in. and up.
2-2½ ft. shrubs should have not less than 6 canes, 2 ft. and up.
2½-3 ft. shrubs should have not less than 7 canes, 2½ ft. and up.
Examples:
Berberis thunbergii atropurpurea, 'Crimson Pigmy'
Deutzia gracilis
Euonymus kiautschovica 'Jewell'
Potentilla fruticosa
Ribes alpinum
Spiraea bumalda 'Anthony Waterer'

COMPARISONS IN THE VARIOUS TYPES OF DECIDUOUS SHRUBS



2.1.5.3 Type 2
18-24 in. shrubs should have not less than 3 canes, 18 in. and up.
2-3 ft. shrubs should have not less than 4 canes, 2 ft. and up.

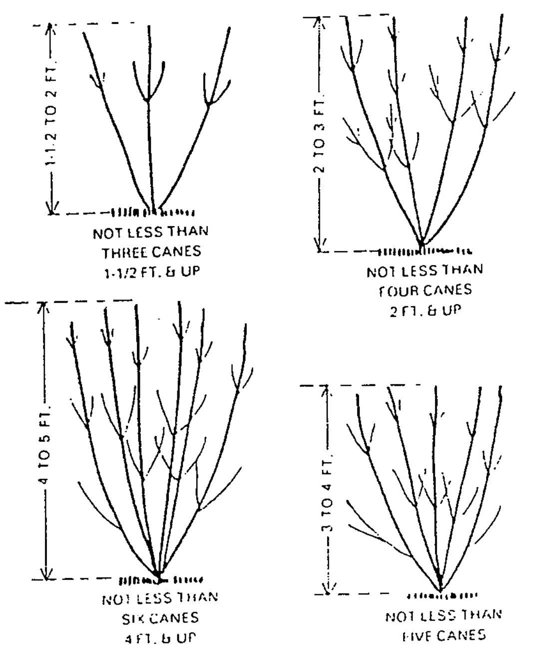
3-4 ft. shrubs should have not less than 5 canes, 3 ft. and up.

4-5 ft. shrubs should have not less than 6 canes, 4 ft. and up.

Examples:

Azalea (deciduous species)
Cephalanthus occidentalis
Cornus alba, sibirica, racemosa, stolonifera
Diervilla sessilifolia
Itea virginica
Kolkwitzia amabilis
Lespedeza thunbergi
Phildelphus lemoinei
Rhodotypos scandens
Rosa multiflora, setigera
Stephanandra incisa

EXAMPLES OF TYPICAL GRADES OR SIZES IN TYPE 2 DECIDUOUS SHRUBS



2.1.5.4 Type 3

18-24 in. shrubs should have not less than 3 canes, 18 in. and up.

2-3 ft. shrubs should have not less than 3 canes, 2 ft. and up.

3-4 ft. shrubs should have not less than 4 canes, 3 ft. and up.

4-5 ft. shrubs should have not less than 5 canes, 4 ft. and up.

Examples:

Acanthopanax sieboldianus
Alnus rugosa
Amelanchier
Aronia arbutifolia, melanocarpa
Calycanthus floridus
Chaenomeles speciosa
Clethra alnifolia
Cornus amomum, sanguinea
Corylus americana, avellana
Cotoneaster acutifolia
Deutzia (tall growing species)
Euonymus americanus
Forsythia
Hamamelis
Hibiscus syriacu
Hydrangea paniculata grandiflora (Peegee H)
Ilex laevigata, verticillata
Kerria japonica (single and double)
Ligustrum obtusifolium regelianum
Lonicera (bush form)
Myrica pensylvanica
Philadelphus virginalis
Prunus amygdalus, cistena, cerasifera, triloba (bush forms)
Rhus canadensis
Rosa blanda, rugosa
Sambucus canadensis, nigra (variegated forms)
Sorbaria aitchisoni, arborea, sorbifolia
Spiraea (tall growing varieties)
Symphoricarpos chenaulti, mollis, occidentalis, albus, orbiculatus
Syringa chinensis, amurensis japonica, josikaea, persica, villosa
Vaccinium corymbosum, stamineum
Viburnum cassinoides, dentatum, lantana, molle, opulus, plicatum, tomentosum, trilobum
Weigela floribunda, florida

2.1.5.5 Type 4

18-24 ft. shrubs should have not less than 2 canes, 18 in. and up.

2-3 ft. shrubs should have not less than 2 canes, 2 ft. and up.

3-4 ft. shrubs should have not less than 3 canes, 3 ft. and up.

4-5 ft. shrubs should have not less than 4 canes, 4 ft. and up.

Examples:

Amorpha fruticosa
Baccharis halimifolia
Caragana arborescens
Chionanthus virginica
Colutea arborescens
Cotinus americanus, coggygria
Cornus alternifolia, mas
Elaeagnus angustifolia, commutata, umbellata
Euonymus alatus, atropurpureus, bungeanus, europaeus, yedoensis
Exochorda racemosa
Halesia carolina
Lespedeza bicolor
Lindera benzoin
Rhamnus cathartica, frangula
Rubus odoratus
Sambucus pubens
Syringa vulgaris
Tamarix
Viburnum lentago, prunifolium

2.1.5.6 Type 5

18-24 in. shrubs with 1 or more canes 18 in. and up in height 5/16 in. cal.

2-3 ft. shrubs with 1 or more canes 2 ft. and up in height 3/8 in. cal.

3-4 ft. shrubs with 1 or more canes 3 ft. and up in height 1/2 in. cal.

4-5 ft. shrubs with 1 or more canes 4 ft. and up in height 5/8 in cal.

5-6 ft. shrubs with 1 or more canes 5 ft. and up in height 7/8 in. cal.

Examples:

Rhus copallina, glabra, typhina

2.1.5.7 Type 6 — Barberry

12-15 in. Berberis thunbergi, 3 canes or more, 12 in. and up.

15-18 in. Berberis thunbergi, 3 canes or more, 15 in. and up.

18-24 in. Berberis thunbergi, 4 canes or more, 18 in. and up.

2-2½ ft. Berberis thunbergi, 4 canes or more, 2 ft. and up.

2½-3 ft. Berberis thunbergi, 5 canes or more, 2½ ft. and up.

3 ft. size Berberis thunbergi, 6 canes or more, 3 ft. and up.

2.1.5.8 Type 7 — Privet (Hedging)

18-24 in. Ligustrum in variety shall have 3 canes or more 18 in. and up

2-3 ft. Ligustrum in variety shall have 4 canes or more 2 ft. and up.

3-4 ft. Ligustrum in variety shall have 5 canes or more 3 ft. and up.

4-5 ft. Ligustrum in variety shall have 6 canes or more 4 ft. and up.

Note: For Ligustrum obtusifolium regalianum, see Type 3

2.2 BARE ROOT SPECIFICATIONS

2.2.1 NURSERY GROWN — SPREAD OF ROOTS

Roots of deciduous shrubs shall have a well-branched root system characteristic of the species. Bare root shrubs shall have minimum root spreads as follows:

Strong Growing Shrubs

Height of Plant	18-24 in.	2-3 ft.	3-4 ft.	4-5 ft.	5-6 ft.	6-8 ft.
Min. Root Spread	10 in.	11 in.	14 in.	16 in.	18 in.	20 in.

2.2.2 COLLECTED — SPREAD OF ROOTS

Shrubs collected from native stands or established plantings must be so designated. The spread of roots, bare root collected, shall be 1/3 greater than the spread of roots of nursery grown shrubs as tabulated above.

Shrubs collected from wild or native stands may be considered nursery grown when they have been successfully re-established in the nursery row and grown under regular nursery cultural practices for a minimum of two growing seasons and have attained adequate root and top growth to indicate full recovery from transplanting into the nursery row.

2.3 BALLING AND BURLAPPING SPECIFICATIONS

Ball sizes should always be of a diameter and depth to encompass enough fibrous and feeding root system necessary for the full recovery of the plant.

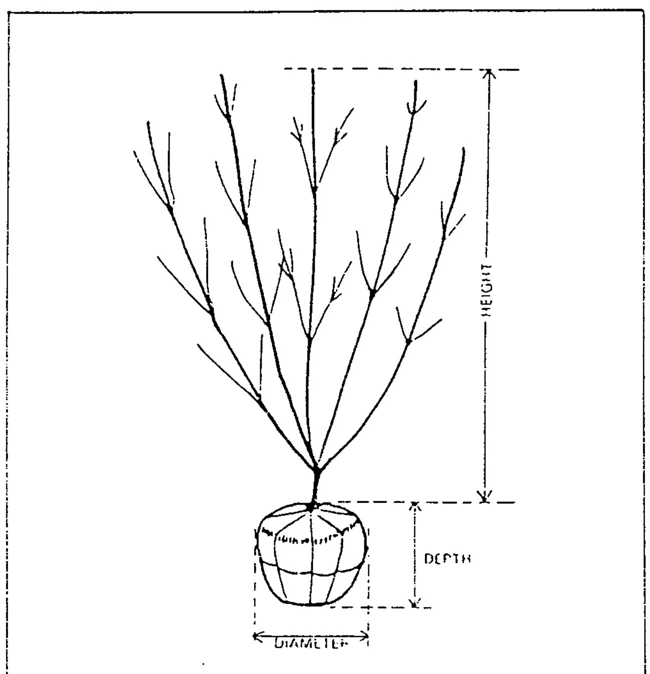
2.3.1 NURSERY GROWN

The following Table represents the recommended minimum sizes of balls for shrubs which are being grown under favorable growing conditions and which have received the proper cultural treatment to develop a well-branched root system.

These specifications are for plants dug with the ball of earth in which they are growing.

Deciduous Shrubs

Height	**Minimum Diameter Ball Inches**
12-18 in.	8
18-24 in.	9
2-3 ft.	10
3-4 ft.	12
4-5 ft.	14
5-6 ft.	16
6-7 ft.	18
7-8 ft.	20
8-9 ft.	22
9-10 ft.	24
10-12 ft.	26



2.3.2 COLLECTED

The minimum sizes of ball shall be equal to those specified in 2.3.1 for the next larger size nursery grown stock.

Shrubs collected from wild or native stands may be considered nursery grown when they have been successfully re-established in the nursery row and grown under regular nursery cultural practices for a minimum of two growing seasons and have attained adequate root and top growth to indicate full recovery from transplanting into the nursery row.

2.3.3 PLANTATION GROWN STOCK

Plants which have been systematically planted in fertile, friable soil which is relatively free of stones and foreign matter, but where there has been a minimum of after-care.

The minimum ball sizes shall be equal to that specified in 2.3.1 for the next larger size nursery grown stock.

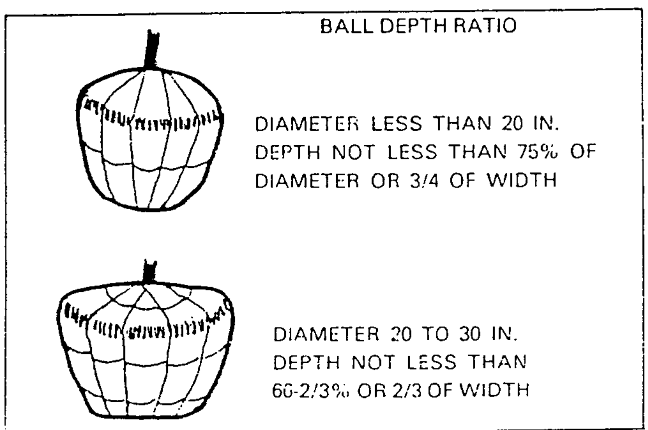
2.3.4 BALL DEPTHS

For the greater part of the country ball depths will carry the following ratios:

Balls with diameters less than 20 inches — Depth not less than 75% of diameter.

Balls with diameters of 20 inches to 30 inches incl. — Depth not less than 66⅔% of diameter.

Under certain soil and regional conditions, plants have root systems of proportionately less depth and greater diameter. These require a more shallow but wider ball to properly encompass the roots. Conversely in other soils and in certain regions roots develop greater depth and less spread, requiring an exceptionally deep ball which may be smaller in diameter and greater in depth than the size recommended.



2.4 CONTAINER GROWN SPECIFICATIONS

All container grown deciduous shrubs shall be healthy, vigorous, well-rooted and established in the container in which they are sold. They shall have tops which are of good quality and are in a healthy growing condition.

An established container grown deciduous shrub shall be a deciduous shrub transplanted into a container and grown in that container sufficiently long for the new fibrous roots to have developed so that the root mass will retain its shape and hold together when removed from the container.

The container shall be sufficiently rigid to hold the ball shape protecting the root mass during shipping.

Dwarf and light growing varieties may be 1 or 2 sizes smaller than standard for a given size container.

The following table gives deciduous shrub sizes and acceptable container sizes:

Height	Container Size
6 to 9 in. 9 to 12 in. 12 to 15 in. 15 to 18 in. 18 to 24 in. 2 to 3 ft.	1 gal. (trade designation) Minimum of 5½ inches across top and height of 6 inches or equivalent volume
12 to 15 in. 15 to 18 in. 18 to 24 in. 2 to 3 ft.	2 gal. (trade designation) Minimum of 7 inches across top and height of 7½ inches or equivalent volume
18 to 24 in. 2 to 3 ft. 3 to 4 ft. 4 to 5 ft.	5 gal., egg can or square can (trade designation) Minimum of 9 inches across top and height of 10 inches or equivalent volume

2.5 BALLED AND POTTED

Balled and potted plants are field-grown nursery plants, dug with a ball of earth still intact in which they are growing, and in lieu of burlapping, are placed in a container to retain the ball unbroken.

Ball sizes shall always be of a diameter and depth to encompass enough fibrous and feeding root system necessary for the full recovery of the plant.

The minimum ball size specification for "balled and potted" plants shall be the same as for "balled and burlapped" plants. (See 2.3.1)

3 CONIFEROUS EVERGREENS

3.1 GENERAL SPECIFICATIONS

3.1.1 QUALITY DEFINITIONS

The quality of evergreens offered is assumed to be normal for the species of variety unless otherwise designated as:

Specimen (Spec.) This designation may be used to indicate exceptionally heavy, well shaped plants and is usually applied to the larger commercial sizes and plants which have been cut back or trimmed to form a perfectly symmetrical, tightly knit plant. The letters "X," "XX," or "XXX" may be used to designate the degree of heavy grades in place of using the word "specimen" (spec.).

Collected. (Coll.) Natural seedling plants dug from native stands or forest plantings must be so designated.

3.1.2 TYPES OF CONIFERS

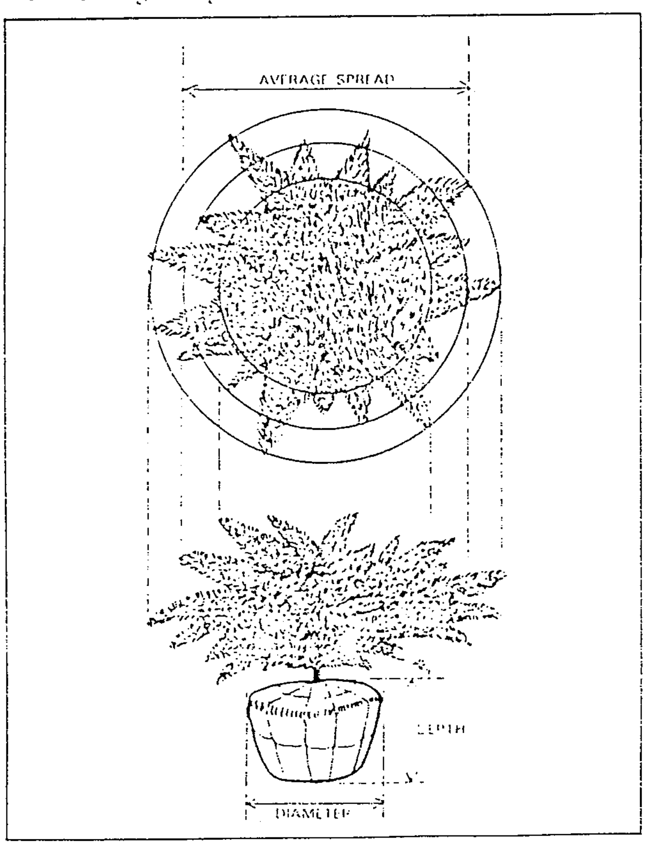
3.1.2.1 Type 1. Creeping or Prostrate Type

Measurement designates spread (height not considered).
Use 3 inch intervals up to 18 inches
Use 6 inch intervals from 18 inches to 4 feet
Use 1 foot intervals from 4 feet up

Measurement should be average of plant and not the greatest diameter. Plants properly trimmed and transplanted should measure the same in any direction. If a plant is uneven, for example, 15 inches the widest way and nine the narrowest, it should be classified as 12" stock.

Examples:

Juniperus horizontalis cultivars
Juniperus procumbens
Pinus mugo mugi us



3.1.2.2 Type 2. Semi-Spreading Type

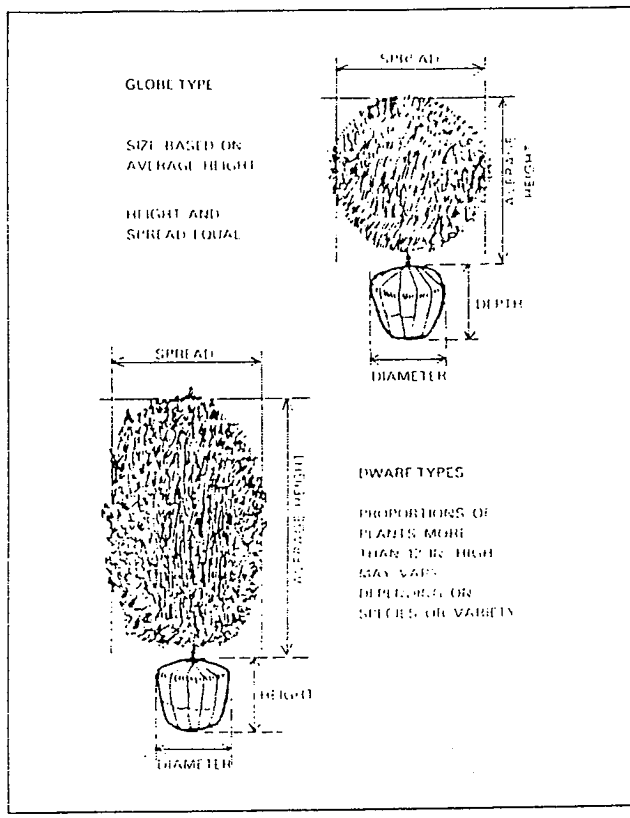
Measurement designates spread.
Use 3 inch intervals up to 18 inches
Use 6 inch intervals from 18 inches to 4 feet
Use 1 foot intervals from 4 feet up
Measurement should be average as in Type 1.

Height will be at least one half of the spread. Above 3 feet the height will be less than the spread, varying somewhat according to natural growth of the particular species and method of handling.

Spread	Height
6 to 9 in. up to 3 ft.	Same as spread
3 to 4 ft.	2½ to 3½ ft.
4 to 5 ft.	3 to 4 ft.

Examples:

Juniperus chinensis pfitzer, sabina
Taxus cuspidata, cuspidata 'Nana', media 'Densiformis'



3.1.2.3 Type 3. Broad Spreading, Globe and Upright Dwarf Types

Measurement designates height.
Use 3 inch intervals up to 18 inches
Use 6 inch intervals from 18 inches to 4 feet
Use 1 foot intervals from 4 feet up

Spread will usually be equal to height in well grown material up to twelve inches. From there on there will be a variation of spread to height depending on the variety.

Height	Spread
6 to 9 in.	min. spread, 6 in.
9 to 12 in.	min. spread, 9 in.
12 to 15 in.	min. spread, 10 in.
15 to 18 in.	min. spread, 12 in.
18 to 24 in.	min. spread, 15 in.
2 to 2½ ft.	min. spread, 18 in.
2½ to 3 ft.	min. spread, 21 in.
3 to 3½ ft.	min. spread, 24 in.

Many broad spreading and globe types included in this classification will usually have the same spread as height (or a greater spread) even in the larger sizes.

Examples:

Chamaecyparis obtusa 'Nana'; pisifera 'Plumosa Nana,' 'Squarrosa Nana'
Juniperus virginiana 'Globe'
Picea abies 'Nidiformis'
Taxus media 'Browni'
Thuja occidentalis 'Globe,' 'Little Gem'

Upright growing dwarf types may approach the minimum dimensions above.

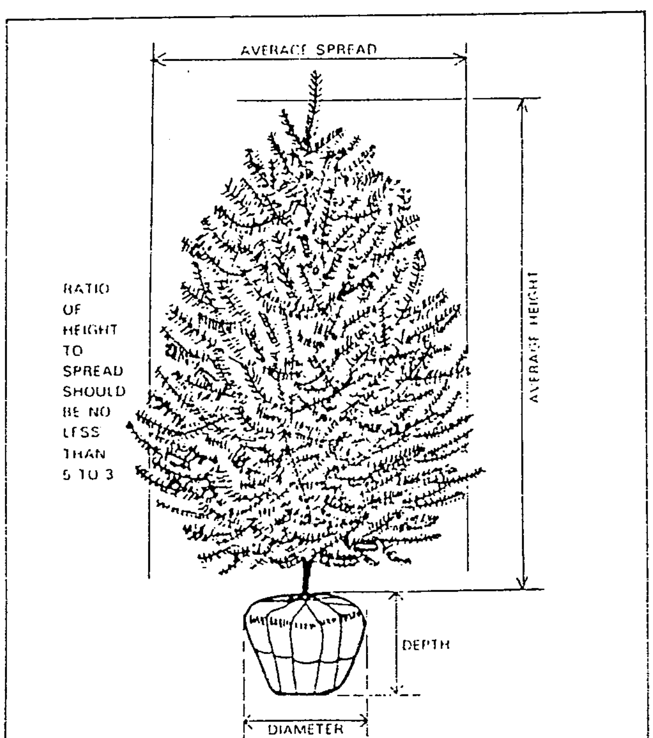
Examples:

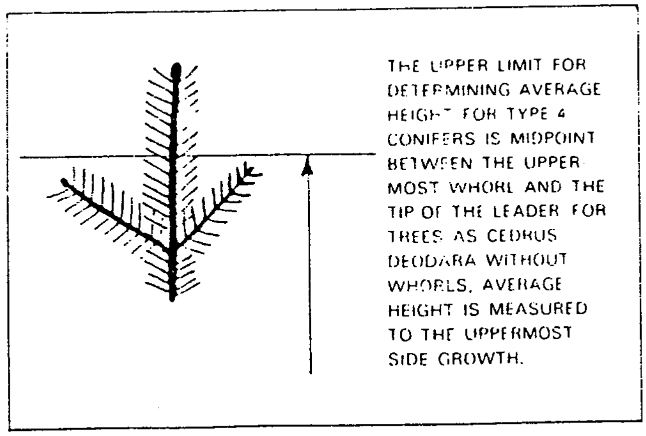
Chamaecyparis obtusa 'Gracilis'
Juniperus squamata 'Mayeri,' excelsa 'Stricta'
Thuja occidentalis 'Hovey,' 'Parsons,' 'Woodward;' orientalis 'Goldbush'

3.1.2.4 Type 4. Cone Type (Pyramidal)

Measurement designates height.
Use 3 inch intervals up to 18 inches
Use 6 inch intervals from 18 inches to 3 feet
Use 1 foot invervals from 3 feet to 10 feet
Use 2 feet intervals from 10 feet up

The ratio of height to spread of properly grown material should not be less than 5 to 3.





Height	Spread
12 to 15 inch	8 to 12 inches
15 to 18 inch	9 to 15 inches
18 to 24 inch	12 to 18 inches
2 to 2½ feet	15 to 21 Inches
2½ to 3 feet	18 to 24 inches
3 to 4 feet	21 to 30 inches
4 to 5 feet	2½ to 3 feet
5 to 6 feet	3 to 4 feet

Examples:

Abies
Cedrus deodara
Chamaecyparis pisifera and varieties (except dwarf types)
Picea abies (conical types)
Pinus (except dwarf type)
Pseudotsuga menzeisi
Taxus cuspidata capitata
Thuja occidentalis, orientalis (conical types)
Tsuga canadensis, caroliniana

3.1.2.5 Type 5. Broad Upright Type

Measurement designates height.
Use 3 inch intervals up to 18 inches
Use 6 inch intervals from 18 inches to 3 feet
Use 1 foot intervals from 3 feet to 10 feet
Use 2 feet intervals from 10 feet up

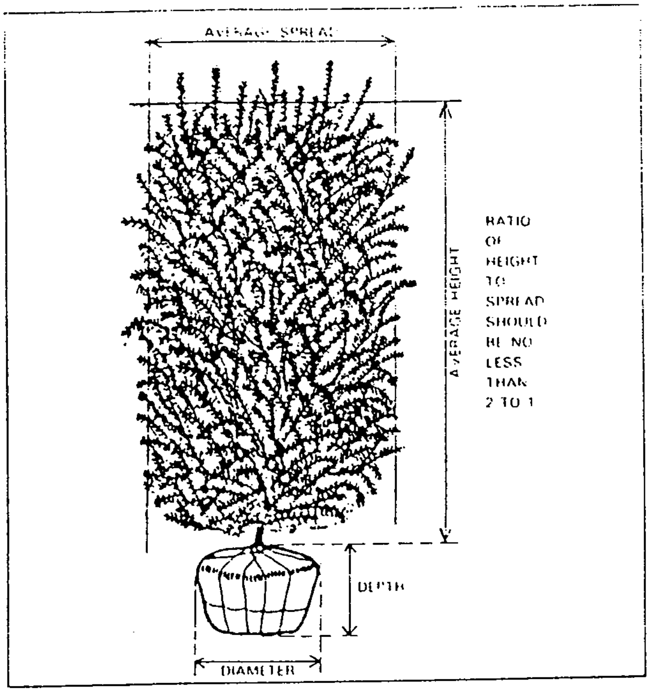
This group includes all the broader, upright growing evergreens which develop a straight sided form with many upright branches of "leaders."

The ratio of height to spread of properly grown material should not be less than 2 to 1.

Height	Spread
12 to 15 inches	8 to 12 inches
15 to 18 inches	9 to 15 inches
18 to 24 inches	12 to 18 inches
2 to 2½ feet	15 to 21 inches
2½ to 3 feet	18 to 24 inches
3 to 4 feet	21 to 30 inches
4 to 5 feet	2½ to 3 feet
5 to 6 feet	3 to 4 feet

Examples:

Chamaecyparis lawsoniana 'Allumii'
Juniperus chinensis 'Keteleeri,' scopulorum
Taxus baccata 'Irish'
Taxus media 'Hicks,' 'Hatfield'



3.1.2.6 Type 6. Columnar Type

Measurement designates height.
Use 3 inch intervals up to 18 inches
Use 6 inch intervals from 18 inches to 3 feet
Use 1 foot intervals from 3 feet to 10 feet
Use 2 feet intervals from 10 feet up

This group includes all the upright growing evergreens which naturally develop a straight sided form or one that tapers only slightly from the ground to a point more than half the height.

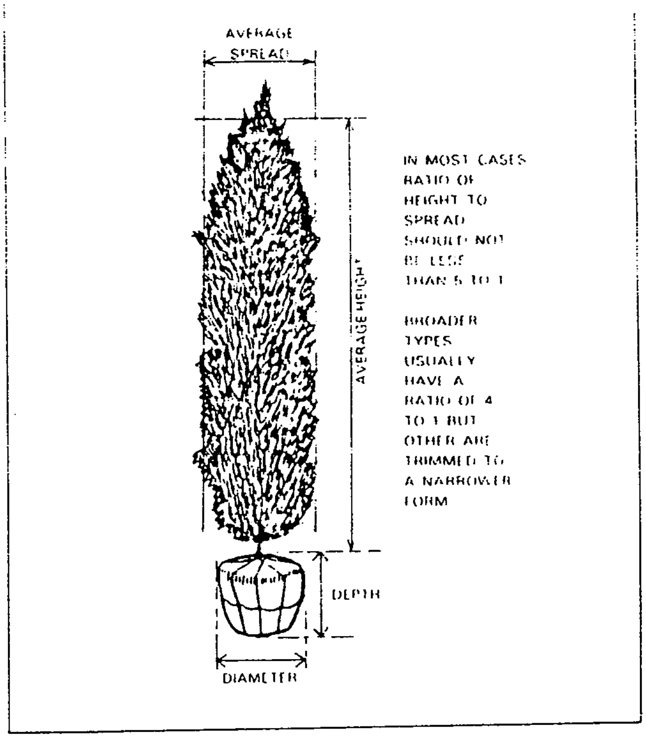
The broader types will usually have a ratio of height to spread of 4 to 1. Many forms, however, will not attain this ratio and even those of broad habit may be trimmed to advantage into a narrowed form. However, in most cases the ratio of height to spread should not be less than 5 to 1.

Height	Spread
12 to 15 inches	3 to 6 inches
15 to 18 inches	4 to 7 inches
18 to 24 inches	5 to 8 inches
2 to 2½ feet	6 to 9 inches
2½ to 3 feet	7 to 10 inches
3 to 4 feet	9 to 12 inches
4 to 5 feet	12 to 15 inches
5 to 6 feet	15 to 18 inches
6 to 7 feet	18 to 21 inches
7 to 8 feet	21 to 24 inches
8 to 10 feet	24 to 30 inches

Examples:
Cupressus sempervirens
Juniperus communis, virginiana (columnar type varieties)
Thuja occidentalis, orientalis (columnar type varieties)

3.2 BALLING AND BURLAPPING SPECIFICATIONS

Ball sizes should always be of a diameter and depth to encompass enough fibrous and feeding root system necessary for the full recovery of the plant.



3.2.1 NURSERY GROWN

The following table represents the recommended minimum sizes of balls for conifers which are being grown in the nursery under favorable growing conditions and which have received the proper cultural treatment to develop a well branched root system.

These specifications are for plants dug with the ball of earth in which they are growing.

Spreading, Semi-Spreading and Globe or Dwarf Type Conifers Types 1, 2 & 3		Cone and Broad Upright Type Conifers Types 4 & 5	
Spread	Minimum Diameter Ball	Height	Minimum Diameter Ball
18-24 in.	10 in.	18-24 in.	10 in.
2-2½ ft.	12 in.	2-3 ft.	12 in.
2½-3 ft.	14 in.	3-4 ft.	14 in.
3-3½ ft.	16 in.	4-5 ft.	16 in.
3½-4 ft.	18 in.	5-6 ft.	20 in.
4-5 ft.	21 in.	6-7 ft.	22 in.
5-6 ft.	24 in.	7-8 ft.	24 in.
6-7 ft.	28 in.	8-9 ft.	27 in.
7-8 ft.	32 in.	9-10 ft.	30 in.
8-9 ft.	36 in.	10-12 ft.	34 in.
		12-14 ft.	38 in.
		14-16 ft.	42 in.
16-18 ft.	46 in.		
		18-20 ft.	50 in.

Columnar Conifers Type 6

Rgular growing kinds		Rapid growing kinds*	
Height	Minimum Diameter Ball	Height	Minimum Diameter Ball
18-24 in.	10 in.	18-24 in.	8 in.
2-3 ft.	12 in.	2-3 ft.	9 in.
3-4 ft.	13 in.	3-4 ft.	11 in.
4-5 ft.	14 in.	4-5 ft.	12 in.
5-6 ft.	16 in.	5-6 ft.	14 in.
6-7 ft.	18 in.		
7-8 ft.	20 in.		
8-9 ft.	22 in.		
9-10 ft.	24 in.		
10-12 ft.	27 in.		
12-14 ft.	30 in.		
14-16 ft.	33 in.		
16-18 ft.	36 in.		
18-20 ft.	40 in.		

*Rapid growing kinds as: Thuja orientalis (Oriental Arborvitae), Juniperus communis 'Stricta' (Irish Juniper).

It is recognized that plants having a coarse or wide-spreading root system because of natural habit of growth, soil condition, infrequent transplanting practice, or that are moved out of season, would require a size of ball in excess of the recommended sizes. It is also recognized that special handling of certain material, such as stock grown in pots or other containers, field plants recently planted out from containers or with smaller balls, or material which has been frequently transplanted or root pruned, constitute cases where the sizes recommended may be excessive.

3.2.2 COLLECTED

The minimum sizes of ball shall be equal to that specified in 3.2.1 for the next larger size nursery grown stock.

Plants collected from wild or native stands may be considered nursery grown when they have been successfully re-established in the nursery row and grown under regular nursery cultural practices for a minimum of two growing-seasons and have attained adequate root and top growth to indicate full recovery from transplanting into the nursery row.

3.2.3 PLANTATION GROWN STOCK

Plants which have been systematically planted in fertile, friable soil which is relatively free of stones and foreign matter, but where there has been a minimum of after-care.

The minimum ball sizes shall be equal to that specified in 3.2.1 for the next larger size nursery grown stock.

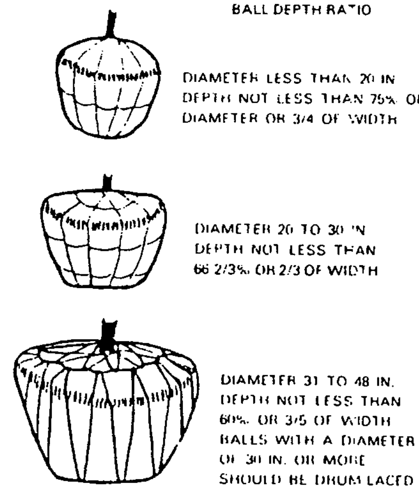
3.2.4 BALL DEPTHS

For the greater part of the country ball depths will carry the following ratios:

Balls with diameters less than 20 inches — Depth not less than 75% of diameter.

Balls with diameters of 20 inches to 30 inches incl. — Depth not less than 66⅔% of diameter.

Balls with diameters of 30 inches to 48 inches incl. — Depth not less than 60% of diameter.



Balls with diameters over 48 inches will have the depth scaled down proportionately.

Under certain soil and regional conditions, plants have root systems of proportionately less depth and greater diameter. These require a more shallow but wider ball to properly encompass the roots. Conversely in other soils and in certain regions roots develop greater depth and less spread, requiring an exceptionally deep ball which may be smaller in diameter and greater in depth than the size recommended.

3.3 CONTAINER GROWN SPECIFICATIONS

All container grown conifers shall be healthy, vigorous, well-rooted and established in the container in which they are sold. They shall have tops which are of good quality and are in a healthy growing condition.

An established container grown conifer shall be a conifer transplanted into a container and grown in that container sufficiently long for the new fibrous roots to have developed so that the root mass will retain its shape and hold together when removed from the container.

The container shall be sufficiently rigid to hold the ball shape protecting the root mass during shipping.

Dwarf and light growing varieties may be 1 or 2 sizes smaller than standard for a given size container.

The following table gives conifer sizes and acceptable container sizes:

3.3.1 TYPES 1, 2 AND 3

Spread (Type 1, Spreading and Type 2, Semi-Spreading Conifers)

Height (Type 3, Globe or Dwarf Conifers)

	Container Size
6 to 9 in. 9 to 12 in. 12 to 15 in.	1 gal. (trade designation) Minimum of 5½ inches across top and height of 6 inches or equivalent volume
12 to 15 in. 15 to 18 in.	2 gal. (trade designation) Minimum of 7 inches across top and height of 7½ inches or equivalent volume

18 to 24 in. 2 to 2½ ft. 2½ to 3 ft.	5 gal., egg can or square can (trade designation) Minimum of 9 inches across top and height of 10 inches or equivalent volume

3.3.2 TYPES 4, 5 AND 6*

Height	Container Size
6 to 9 in. 9 to 12 in. 12 to 15 in. 15 to 18 in. 18 to 24 in.	1 gal. (trade designation) Minimum of 5½ inches across top and height of 6 inches or equivalent volume
12 to 15 in. 15 to 18 in. 18 to 24 in. 2 to 2½ ft.	2 gal. (trade designation) Minimum of 7 inches across top and height of 7½ inches or equivalent volume
18 to 24 in. 2 to 2½ ft. 2½ to 3 ft. 3 to 3½ ft. 3½ to 4 ft.	5 gal., egg can, or square can (trade designation) Minimum of 9 inches across top and height of 10 inches or equivalent volume

*Except for extreme columnar types as Cupressus sempervirens (Italian cypress) which is acceptable 1 or 2 sizes taller than standard for a given container.

3.4 BALLED AND POTTED

Balled and potted plants are field-grown nursery plants, dug with a ball of earth still intact in which they are growing, and in lieu of burlapping, are placed in a container to retain the ball unbroken.

Ball sizes shall always be of a diameter and depth to encompass enough fibrous and feeding root system necessary for the full recovery of the plant.

The minimum ball size specification for "balled and potted" plants shall be the same as for "balled and burlapped" plants. (See 3.2.1)

4 BROADLEAF EVERGREENS

4.1 GENERAL SPECIFICATIONS

4.1.1 QUALITY DEFINITIONS

The quality of evergreens offered is assumed to be normal for the species or variety unless otherwise designated as:

Collected. (Coll.) Natural seedling plants dug from native stands or forest plantings must be so designated.

4.1.2 GRADING TOLERANCE

The growing of plant material cannot be rigidly standardized because of varying conditions of growth and methods of handling preferred or necessitated by climate, soil, and other conditions beyond the control of the grower. Judgment should therefore be exercised and allowances made in the above definitions to agree with those which are recognized by the trade as typical of acceptable plants in that region.

Where a minimum and maximum size, i.e. size range is specified, the average of the lot shall approximate the mid-point of the specified size range. Plant lots of a given height shall have an approximate average as in the following examples:

Height of Plant	18-24 in.	2-3 ft.	3-4 ft.	4-5 ft., etc.
Average of Lot	21 in.	2½ ft.	3½ ft.	4½ ft.

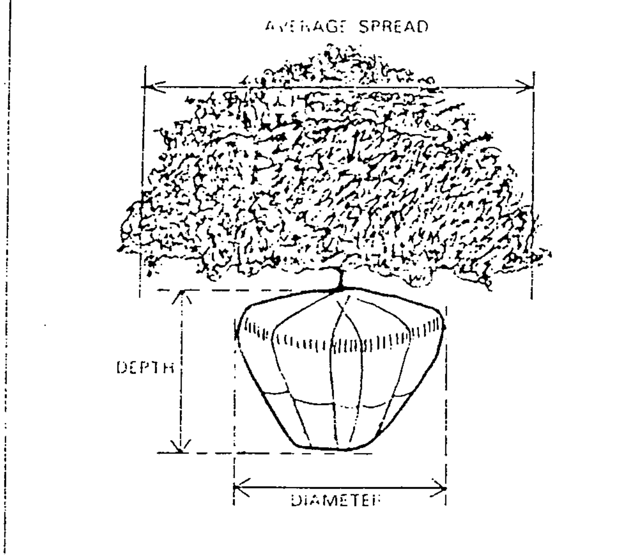
4.1.3 TYPES AND MEASUREMENT DESIGNATION

Measurement of height should begin at the ground line and should continue up to where the main part of the plant ends and not to the tip of a thin shoot.

Five general types or groups are considered separately as follows:

4.1.3.1 Type 1 Spreading Type

Measurement designates spread (height not considered).
Use 3 inch intervals up to 18 inches.
Use 6 inch intervals from 18 inches to 4 feet
Use 1 foot intervals over 4 feet.



Examples:

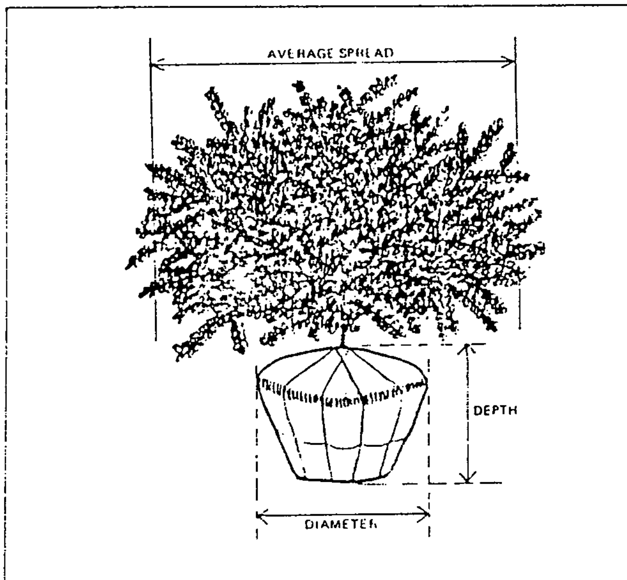
Calluna vulgaris (and cultivars)
Carissa grandiflora 'Green Carpet'
Cotoneaster dammeri, horizontalis (and cultivars)
Cytisus 'Lydia'
Ilex crenata 'Helleri'
Mahonia nervosa, repens

4.1.3.2 Type 2 Semi-Spreading Type

Measurement designates spread (height not considered).
Use 3 inch intervals up to 18 inches.
Use 6 inch intervals up to 18 inches to 4 feet.
Use 1 foot intervals over 4 feet.

Examples:

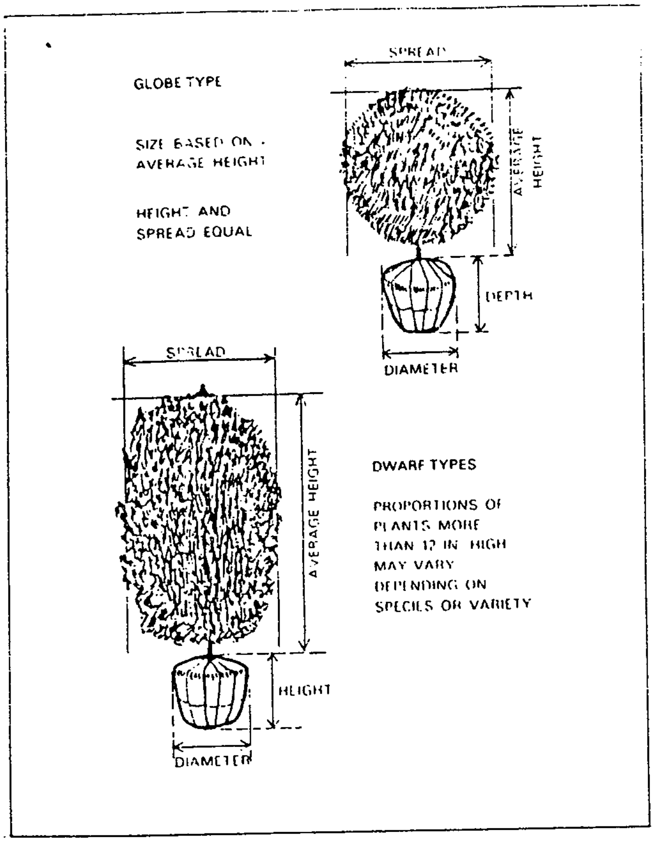
Berberis verruculosa
Cotoneaster francheti, salicifolia
Daphne odora
Ilex crenata 'Convexa', 'Hetzi'
Leucothoe axillaria, catesbaei
Pieris floribunda
Raphiolepis umbellata
Rhododendron (Azalea) obtusum 'Amoenum,' Gumpo & Kurume types
Rhododendron impeditum



4.1.3.3 Type 3 Globe or Dwarf Type

Measurement designates height.
Use 3 inch intervals up to 18 inches.
Use 6 inch intervals from 18 inches to 4 feet.
Use 1 foot intervals from 4 feet up.

Spread will usually be equal to or only slightly less than the height up to 12 inches. From there on the spread may be less than the height but in no case will the ratio be more than 2 to 1 or height more than twice the spread. Both dimensions may be given, as it would be a good practice.



Height	Minimum Spread
6 to 9 inches	min. spread 5 inches
9 to 12 inches	min. spread 6 inches
12 to 15 inches	min. spread 7 inches
15 to 18 inches	min. spread 9 inches
18 to 24 inches	min. spread 10 inches
2 to 2½ feet	min. spread 14 inches

Examples:

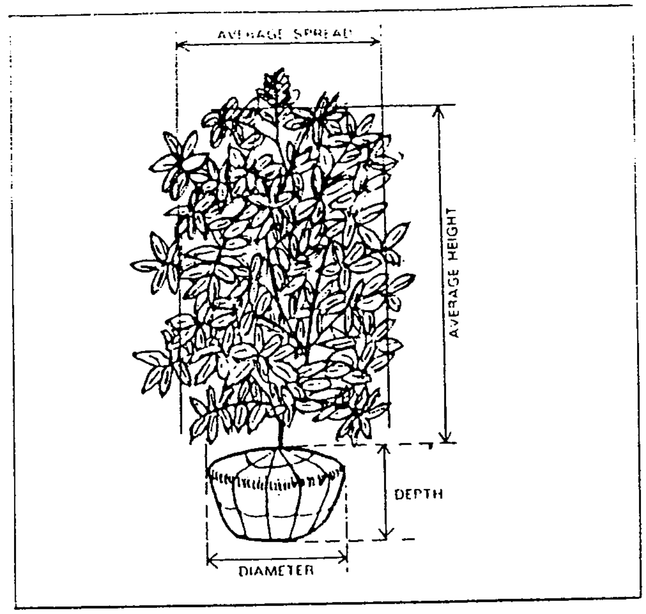
Buxus microphylla (dwarf cultivars), sempervirens 'Suffruticosa'
Ilex cornuta 'Rotunda,' vomitoria 'Nana'
Leiophyllum buxifolium

4.1.3.4 Type 4 Broad Upright Type

Measurement designates height.
Use 3 inch intervals up to 18 inches.
Use 6 inch intervals from 18 inches to 3 feet.
Use 1 foot intervals from 3 feet up.

This group includes all of the larger growing upright "broadleaves" which vary considerably in ratio of spread to height. Well grown material will in most cases have a height equal to if not greater than the spread. However, the spread should not be less than two-thirds of the height.

Height	Minimum Spread
12 to 15 inches	min. spread 8 inches
15 to 18 inches	min. spread 10 inches
18 to 24 inches	min. spread 12 inches
2 to 2½ feet	min. spread 16 inches
2½ to 3 feet	min. spread 20 inches
3 to 4 feet	min. spread 24 inches
4 to 5 feet	min. spread 28 inches



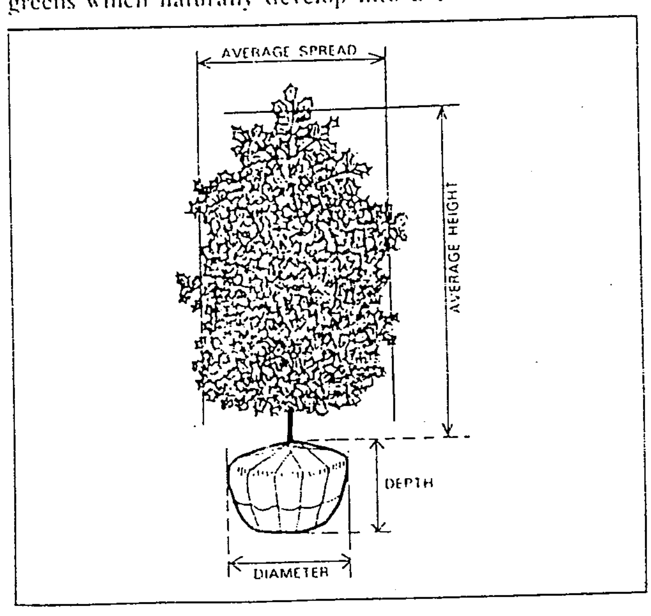
Examples:

Abelia grandiflora
Aucuba japonica (and cultivars)
Azalea 'Rosebud'
Berberis julianae
Cytisus 'Burkwoodi'
Elaeagnus pungens
Gardenia jasminoides
Ilex cornuta (and cultivars), crenata 'Rotundifolia'
Kalmia latifolia
Ligustrum lucidum, texanum
Mahonia aquifolium
Pieris japonica
Rhododendron (cultivars)
Viburnum rhytidophyllum, tinus

4.1.3.5 Type 5 Cone Type

Specifications identical to Type 4.

This type includes all upright growing broadleaf evergreens which naturally develop into a conical form. Well



grown material will have a ratio of height to spread of [illegible] to 2. However a greater spread is acceptable.

Examples:
- Ilex aquifolium, opaca (and cultivars
- Ilex hybrids as 'Foster #2' and 'Nellis R. Stevens'
- Camellia japonica, sasanqua
- Illicium anisatum
- Prunus caroliniana, laurocerasus, lusitanica

4.2 BALLING AND BURLAPPING SPECIFICATIONS

Ball sizes should always be of a diameter and depth to encompass enough fibrous and feeding root system necessary for the full recovery of the plant.

4.2.1 NURSERY GROWN

The following table represents the recommended minimum sizes of balls for broadleaf evergreens which are being grown in the nursery under favorable growing conditions and which have received the proper cultural treatment to develop a well branched root system.

These specifications are for plants dug with the ball of earth in which they are growing.

Spreading, Semi-Spreading and Globe or Dwarf Broadleaf Evergreens Types 1, 2 & 3		Cone and Broad up-right Type Broadleaf Evergreens Types 4 & 5	
Spread	**Minimum Diameter Ball**	**Height**	**Minimum Diameter Ball**
18-24 in.	10 in.	18-24 in.	10 in.
2-2½ ft.	12 in.	2-3 ft.	12 in.
2½-3 ft.	14 in.	3-4 ft.	14 in.
3-3½ ft.	16 in.	4-5 ft.	16 in.
3½-4 ft.	18 in.	5-6 ft.	20 in.
4-5 ft.	21 in.	6-7 ft.	22 in.
		7-8 ft.	24 in.
		8-9 ft.	27 in.
		9-10 ft.	30 in.
		10-12 ft.	34 in.
		12-14 ft.	38 in.
		14-16 ft.	42 in.
		16-18 ft.	46 in.
		18-20 ft.	50 in.

It is recognized that plants having a coarse or wide-spreading root system because of natural habit of growth, soil condition, infrequent transplanting practice, or that are moved out of season, would require a size of ball in excess of the recommended sizes. It is also recognized that special handling of certain material, such as stock grown in pots or other containers, field plants recently planted out from containers or with smaller balls, or material which has been frequently transplanted or root pruned, constitute cases where the sizes recommended may be excessive.

4.2.2 COLLECTED

The minimum sizes of ball shall be equal to that specified in 4.2.1 for the next larger size nursery grown stock.

Plants collected from wild or native stands may be considered nursery grown when they have been successfully re-established in the nursery row and grown under regular nursery cultural practices for a minimum of two growing seasons and have attained adequate root and top growth to indicate full recovery from transplanting into the nursery row.

4.2.3 PLANTATION GROWN STOCK

Plants which have been systematically planted in fertile, friable soil which is relatively free of stones and foreign matter, but where there has been a minimum of after-care.

The minimum ball sizes shall be equal to that specified in 4.2.1 for the next larger size nursery grown stock.

4.2.4 BALL DEPTHS

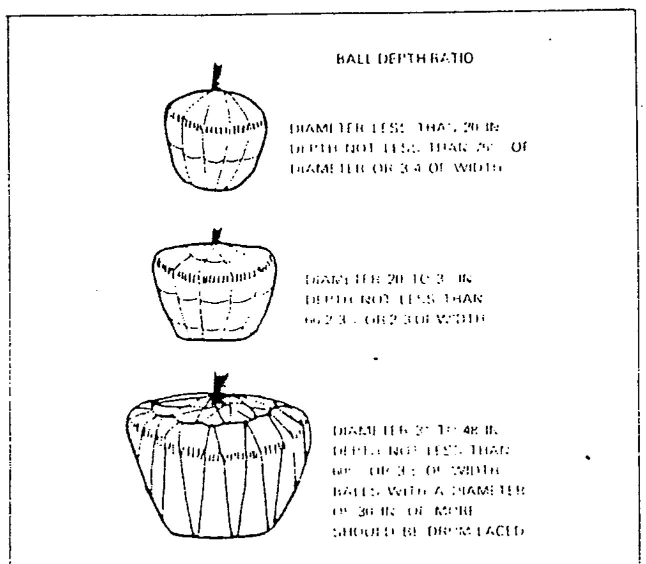
For the greater part of the country ball depths will carry the following ratios:

Balls with diameters less than 20 inches — Depth not less than 75% of diameter.

Balls with diameters of 20 inches to 30 inches incl. — Depth not less than 66⅔% of diameter.

Balls with diameters of 30 inches to 48 inches incl. — Depth not less than 60% of diameter.

Ball with diameters over 48 inches will have the depth scaled down proportionately.



Under certain soil and regional conditions, plants have root systems of proportionately less depth and greater diameter. These require a more shallow but wider ball to properly encompass the roots. Conversely in other soils and in certain regions roots develop greater depth and less spread, requiring an exceptionally deep ball which may be smaller in diameter and greater in depth that the size recommended.

4.3 CONTAINER GROWN SPECIFICATIONS

All container grown broadleaf evergreens shall be healthy, vigorous, well-rooted and established in the container in which they are sold. They shall have tops which are of good quality and are in a healthy growing condition.

An established container grown broadleaf evergreen shall be a broadleaf evergreen transplanted into a container and grown in that container sufficiently long for the new fibrous roots to have developed so that the root mass will retain its shape and hold together when removed from the container.

The container shall be sufficiently rigid to hold the ball shape protecting the root mass during shipping.

Dwarf and light growing varieties may be 1 or 2 sizes smaller than standard for a given container.

The following table gives broadleaf evergreen sizes and acceptable container sizes:

4.3.1 TYPES 1, 2 AND 3 BROADLEAF EVERGREENS

Spread (Type 1, Spreading and
Type 2, Semi-Spreading)

Height (Type 3, Dwarf or Globe)

	Container Size
6 to 9 in. 9 to 12 in. 12 to 15 in.	1 gal. (trade designation) Minimum of 5½ inches across top and height of 6 inches or equivalent volume
12 to 15 in. 15 to 18 in.	2 gal. (trade designation) Minimum of 7 inches across top and height of 7½ inches or equivalent volume
18 to 24 in. 2 to 2½ ft. 2½ to 3 ft.	5 gal., egg can or square can (trade designation) Minimum of 9 inches across top and height of 10 inches or equivalent volume

4.3.2 TYPE 4, BROAD UPRIGHT TYPE AND TYPE 5, CONE TYPE* BROADLEAF EVERGREENS

Height	**Container Size**
6 to 9 in. 9 to 12 in. 12 to 15 in. 15 to 18 in. 18 to 24 in.	1 gal. (trade designation) Minimum of 5½ inches across top and height of 6 inches or equivalent volume
12 to 15 in. 15 to 18 in. 18 to 24 in. 2 to 2½ ft.	2 gal. (trade designation) Minimum of 7 inches across top and height of 7½ inches or equivalent volume
18 to 24 in. 2 to 2½ ft. 2½ to 3 ft. 3 to 3½ ft. 3½ to 4 ft.	5 gal., egg can, or square can (trade designation) Minimum of 9 inches across top and height of 10 inches or equivalent volume

*Except for extreme columnar types as Prunus laurocerasus (Cherry Laurel) and Ligustrum japonicum (Japanese Privet) which are acceptable 1 or 2 sizes taller than standard for a given container.

4.4 BALLED AND POTTED

Balled and potted plants are field-grown nursery plants, dug with a ball of earth still intact in which they are growing, and in lieu of burlapping, are placed in a container to retain the ball unbroken.

Ball sizes shall always be of a diameter and depth to encompass enough fibrous and feeding root system necessary for the full recovery of the plant.

The minimum ball size specification for "balled and potted" plants shall be the same as for "balled and burlapped" plants. (See 4.2.1)

5 ROSE GRADES

5.1 GENERAL

The standards specified apply only to field grown two year Roses when sold either bare root or individually wrapped and packaged, or in cartons.

All grades of roses must have a well-developed root system and have proportionate weight and caliper according to grade and variety. Roses shall be graded by size, number and length of canes, and proper consideration should be given to weight and caliper of canes, depending upon grade and variety.

The specifications outlined for length of canes are applicable before pruning in preparation for sale.

Rose bushes that do not meet these standards for the individual grades are defined as CULLS.

5.2 HYBRID TEA, TEA, GRANDIFLORA, HYBRID PERPETUAL, MOSS AND MISCELLANEOUS BUSH ROSES

Grade No. 1

3 or more strong canes, two of which are to be 18 inches and up, with the exception of a few of the light growing sorts*, which are to have three or more canes, two of which are to be 16 inches and up, and one cane to be 18 inches and up, branched not higher than 3 inches above the bud union.

Grade No. 1½ or Medium

2 or more strong canes, to be 15 inches and up with the exception of a few of the light growing sorts*, which are to have 2 strong canes 13 inches and up, branched not higher than 3 inches above the bud union.

Grade No. 2

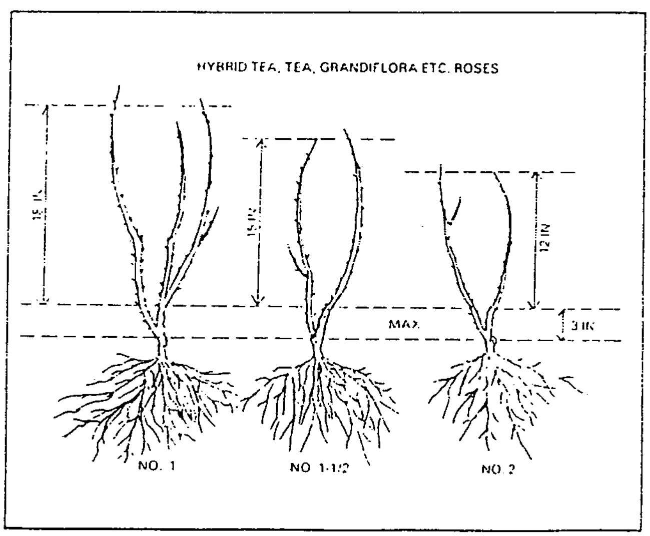
2 or more strong canes 12 inches and up, with the exception of a few light growing sorts*, which are to have 2 or more canes, 10 inches and up, branched not higher than 3 inches above the bud union.

*Many varieties of Hybrid Tea Roses express varying growth characteristics in different parts of the country. Some varieties may be generally known to be less vigorous in some regions than in others. The term used above, "light growing sorts" cannot therefore be used in a universal or rigid sense. Examples of varieties generally considered to be "light growing" are:

'President Hoover'
'Etoile de Holland'
'The Doctor'
'Mojave'

Other examples that are often considered in some areas as "light growing varieties" are:

'New Yorker'
'Charlotte Armstrong'
'Helen Traubel'



5.3 FLORIBUNDA ROSES

Grade No. 1

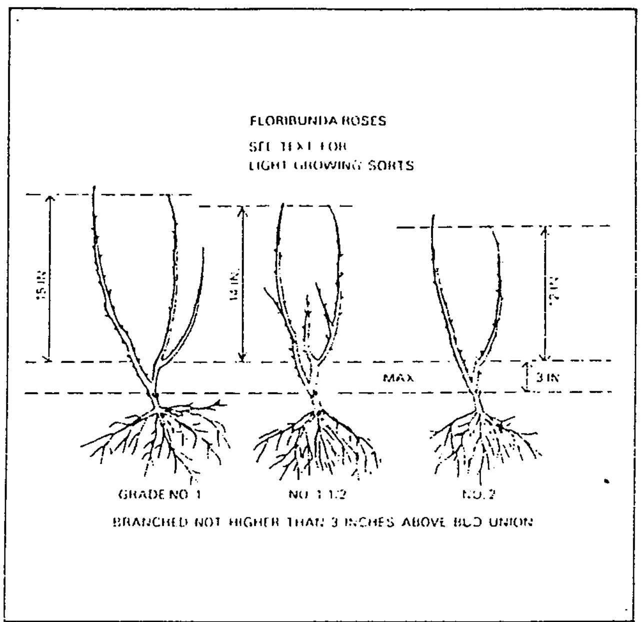
3 or more strong canes, 2 of which are to be 15 inches and up branched not higher than 3 inches above the bud union.

Grade No. 1½ or Medium

2 or more strong canes to be 14 inches and up, branched not higher than 3 inches above the bud union.

Grade No. 2

2 or more strong canes to be 12 inches and up branched not higher than 3 inches above the bud union.



5.4 POLYANTHA, DWARF AND LIGHT GROWING FLORIBUNDA ROSES

Grade No. 1

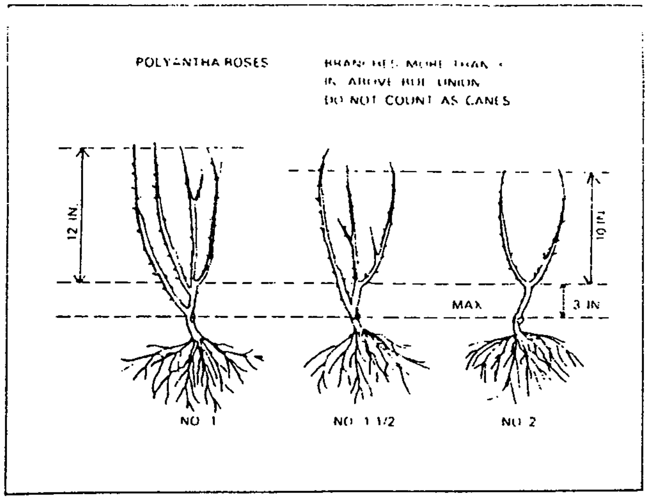
to have 4 or more canes, all to be 12 inches and up and branched not higher than 3 inches above the bud union.

Grade No. 1½ or Medium

to have 3 or more canes, all to be 10 inches and up and branched not higher than 3 inches above the bud union.

Grade No. 2

2 or more strong canes, both to be 10 inches and up and branched not higher than 3 inches above the bud union.



5.5 CLIMBING ROSES

Grade No. 1

to have 3 or more strong canes, 24 inches and up, branched not higher than 3 inches above the bud union or crown.

Grade No. 1½ or Medium

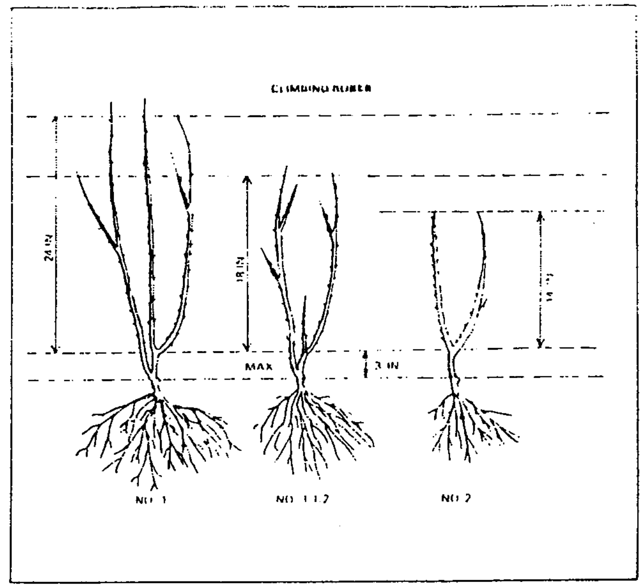
to have 2 strong canes, each 18 inches and up, branched not higher than 3 inches above the bud union or crown.

Grade No. 2

To have 2 strong canes each 14 inches and up, branched not higher than 3 inches above the bud union or crown.

5.6 CONTAINER GROWN ROSES

All container grown roses shall have been growing in the container in which they are marketed for a minimum of one



month of active growing season and for a maximum of two growing seasons. Roses may be cut back to a minimum of 4 inches above the bud union at the time they are potted, and still comply with the grades in which they were classified prior to pruning in preparation for potting.

Grade of Roses	Minimum Container Size
No. 1	2 gal. (trade designation) Minimum of 7 inches across top and height of 7½ inches or equivalent volume
No. 1½ and No. 2	1 gal. (trade designation) Minimum of 5½ inches across top and height of 6 inches or equivalent volume

6 VINES & GROUND COVERS

6.1 TYPE 1 — FAST GROWING VINES

The fast growing vines which normally produce a number of vigorous woody runners in one or two years shall be graded and designated as follows:

2 year, number 1 — shall have heavy well branched tops with not less than 3 runners 18 inches and up and vigorous well developed root system.

2 year, number 2 — lighter grade below number 1 standard but without serious defects, 3 runners 12 inches and up and a root system commensurate with the top.

Older vines should be designated according to age, heavy or light grade, length of runners, and other characteristics such as standard, grafted, potted, or tubbed.

Examples:

Celastrus orbiculata, scandens
Lonicera japonica, halliana, sempervirens
Parthenocissus quinquefolia, engelmanni
Rosa wichuraiana
Wisteria

6.2 TYPE 2 — MEDIUM GROWING VINES

Woody vines usually starting with a single cane or runner should be designated by age and grade — heavy and light.

2 year, number 1 — shall have a heavy well branched top and vigorous well developed root system.

2 year, medium — lighter grade than the above without serious defects, top not as well branched. However, root system must be in porportion to top.

Older vines should be designated according to age, heavy or light grades, length of runners, and other characteristics such as standard, grafted, potted, or tubbed.

Examples:

Actinidia
Aristolochia
Campsis (Bignonia) radicans
Parthenocissus tricuspidata veitchi
Vitis

6.3 TYPE 3 — CLUMP TYPE

Clump type shall be designated by age and heavy or light grade. Dormant plants may or may not have live runners. In this group a well developed root system and healthy well developed crown are the important considerations.

Examples:

Clematis
Pueraria (Kudzu)

6.4 TYPE 4 — GROUND COVERS

Dwarf vines and ground covers are to be designated or described by age, size of clump, length of vines or runners, and/or other characteristics indicative of the species or cultivars listed.

Examples:

Arctostaphylos uva-ursi
Cornus canadensis
Cotoneaster dammeri
Hedera helix (and cultivars)
Euonymus fortunei (botanical varieties and cultivars)
Pachysandra terminalis
Vinca minor, major (and cultivars)

6.5 TYPE 5 — GROUND COVER — CROWNVETCH

Clump type shall be designated by age, runner length and container. Dormant plants may or may not have live runners. In this type a well developed root system and healthy, well developed crown are the important considerations.

Field grown crownvetch shall be whole crowns, at least one growing season old. The overall length of the plant shall be 6-9 in., including ½ in. of top growth and the root caliper 1 in. below the root collar shall measure no less than 1/8 in.

Crownvetch produced in pots or other media-holding containers will be grown in sizes adequate for the age and grade and will be acclimated to conditions befitting the planting season.

6.6 VINES IN POTS OR CONTAINERS

Ground covers supplied in pots or similar containers shall be thrifty, well-balanced plants, well established in the containers.

The following are suggested minimum specifications:

Variety	Size of Pot	Min. No. of Runners	Min. Length of Runners
Ajuga reptans and cultivars	2¼ in., 4 in., gal.	—	—
Euonymus fortunei and cultivars	2¼ in.	2	8 in.
"	3 in.	3	10 in.
"	4 in.	4	12 in.
"	gal.	6	12 in.
Hedera helix and cultivars	2¼ in.	1	8 in.
"	3 in.	2	10 in.
"	4 in.	3	10 in.
"	gal.	4	10 in.
Lonicera jap. halliana	2¼ in.	2	4 in.
"	3 in.	3	6 in.
"	4 in.	4	8 in.
Pachysandra terminalis	2¼ in., 3 in., 4 in.	—	—
Vinca minor, major and cultivars	2¼ in.	3 to 6	6 to 8 in.
"	3 in.	6 to 8	8 to 10
"	4 in.	10 to 12	8 to 10 in.

Collected (Coll.) — Plants collected from the wild must be so designated.

7 FRUIT TREE GRADES

7.1 DECIDUOUS

7.1.1 GENERAL

All trees should have reasonably straight bodies according to habit of growth.

All grades five-sixteenths and larger should be branched except one year Sweet Cherry, and well rooted. The nine-sixteenths and eleven-sixteenths should have three, or more side branches. Caliper should be taken two inches above the collar or bud. Height shall be taken from the collar if grafted or from the union of the bud and stock if budded.

The caliper shall govern, height being intended to represent average height of most varieties. Slow growing kinds may fall short of height specified. Age should be given as one year, two years, etc.

Caliper (in inches)	Minimum Heights

APPLE—Standard, CHERRY—Sweet, PEACH, PEAR—Standard & PLUM (1 and 2 years)

11/16 and up	4½ ft. and up
9/16 to 11/16	4 ft. and up
7/16 to 9/16	3 ft. and up
5/16 to 7/16	2 ft. and up

PEAR—Dwarf & QUINCE

9/16 and up	3½ ft. and up
7/16 to 9/16	3 ft. and up
5/16 to 7/16	2 ft. and up

APPLE—Dwarf

9/16 and up	3½ ft. and up
7/16 to 9/16	2½ ft. and up
5/16 to 7/16	2 ft. and up

APRICOT

11/16 and up	4 ft. and up
9/16 to 11/16	3 ft. and up
7/16 to 9/16	2½ ft. and up
5/16 to 7/16	2 ft. and up

CHERRY—Sour

11/16 to 1 in., 2 years	4 ft. and up
9/16 to 11/16, 2 years	3½ ft. and up
7/16 to 9/16, 2 years	3 ft. and up
5/16 to 7/16, 2 years	2 ft. and up
11/16 and up, 1 year	3½ ft. and up
9/16 to 11/16, 1 year	3 ft. and up
7/16 to 9/16, 1 year	2½ ft. and up
5/16 to 7/16, 1 year	2 ft. and up

7.1.2 ONE YEAR STANDARD

It is accepted practice in the three West Coast states, Washington, Oregon and California, to grade one year old standard fruit tree stock (apples, pears, cherries, plums, peaches, nectarines, apricot and quince) in intervals of 1/8 inch as follows:

1 yr. 3/4 inch and up
1 yr. 5/8 inch and up
1 yr. 1/2 inch to 5/8 inch
1 yr. 3/8 inch to 1/2 inch
1 yr. 1/4 inch to 3/8 inch

7.1.3 SEEDLINGS

7.1.3.1 Caliper Measurement

Caliper shall be taken at the collar or ground line and grade shall correspond to the following caliper:

3/8 in. — 3/8 in. to 7/16 in.
1/4 in. — 1/4 in. to 3/8 in.
No. 1 — 3/16 in. to 1/4 in.
No. 2 — 1/8 in. to 3/16 in.
No. 3 — 1½/16 in. to 2/16 in.
No. 4 — 1/16 in. to 1½/16 in.

Exception: Grade No. 1 "Straight" of Apple Seedlings shall be graded from 3/16" to 5/16" caliper.

7.1.3.2 Special Specifications:

In the case of seedlings with limbs there shall be at least two inches above the collar free of limbs for one-half the circumference of the seedling.

In case of Apple and Pear Seedlings where the root description is given as branched or straight, the following shall apply:

Branched Root — Not less than three root branches and point of branching shall be not more than four inches from the collar.

Straight Root — The root shall carry the caliper of the grade for not less than six inches from the collar.

In the case of "cutting" grown stock, the caliper shall be taken on the original "cutting," at the collar.

7.2 CITRUS

Citrus stocks are to be graded according to 1/8 inch series as follows: 3/8 to 1/2 inch; 1/2 inch to 5/8 inch; 5/8 inch to 3/4 inch; 3/4 inch to 1 inch; 1 inch to 1¼ inches.

Age in years is to be given; that is one or two years. Caliper is to be taken 1/2 inch above the bud union. Minimum size to be 3/8 inch except that tangerine, mandarin or lime trees may be sold in 5/16 to 3/8 inch caliper.

8 SMALL FRUITS

All small fruit plants must be well rooted. No injured, dwarfed or odd shape plants shall be included in any grade.

8.1 RASPBERRIES

8.1.1 SUCKER AND ROOT CUTTING PLANTS

GRADE NO. 1

Sucker and root cutting plants, also tip plants, should be graded 3/16 inch and up in caliper at collar; sucker plants should have 10 inches or more of live top; tip plants, 8 inches or more live tops; and well rooted.

GRADE NO. 2

Sucker and root cutting plants, also tip plants, 1/8 inch and up in caliper at collar; sucker and root cutting plants to have 8 inches or more of live top; tip plants, 6 inches or more of live tops, and all proportionately well rooted.

8.1.2 TRANSPLANTED RASPBERRIES

GRADE NO. 1

All transplanted raspberries should caliper 1/4 inch and up at collar and have 15 inches or more of live top, and be well rooted.

GRADE NO. 2

Number two must caliper 3/16 inch and up with 12 inches or more of live top, and be well rooted.

8.2 DEWBERRIES, BLACKBERRIES, BOYSENBERRIES, YOUNGBERRIES

8.2.1 ROOT CUTTINGS

GRADE NO. 1

Root cuttings should caliper 1/8 inch and sucker plants should caliper 3/16 inch and up at collar and have 12 inches or more of live top, and be well rooted.

GRADE NO. 2

Root cuttings should caliper 3/32 inch and up and sucker plants should caliper 1/8 inch and up at collar and have 8 inches or more of live top, and be proportionately well rooted.

8.2.2 TRANSPLANTED BLACKBERRIES

GRADE NO. 1

Should caliper 1/4 inch and up at collar and have 12 inches or more of live top, and be well rooted.

8.3 CURRANTS

GRADE 2 YR. NO. 1

Shall measure 12 inches and up in height, with two or more branches, and be well rooted.

GRADE 1 YR. NO. 1

Shall measure 9 inches and up in height; if single cane plants, to be 12 inches high, and be well rooted.

GRADE 2 YR. NO. 2

Same specifications as 1 Yr. No. 1.

8.4 BLUEBERRIES

All measurements to indicate overall height of plant from crown to tip of plants. All well rooted and well branched in proportion to height.

1 year Rooted Cuttings	3-6 in.
2 year No. 1	9-12 in.
2 year No. 2	6-9 in.
3 year No. 1	12-18 in.
4 year No. 1	18-24 in.

8.5 GOOSEBERRIES

GRADE 2 YR. NO. 1

Shall measure 12 inches and up in height, with three or more canes, or equivalent side branches, and be well rooted.

GRADE 1 YR. NO. 1

Shall measure 8 inches and up in height, with two or more branches, or equivalent side branches, and be well rooted.

GRADE 2 YR. NO. 2

Same specifications as 1 Yr. No. 1.

8.6 GRAPE VINES

Grading of Grape Vines is based mainly on root system.

GRADE 2 YR. NO. 1

The lightest growing varieties should have 12 inches or more of live top; stronger growing varieties should be proportionately larger and all well rooted.

GRADE 1 YR. NO. 1

Lightest growers should have 6 inches or more of live top; stronger growers should be proportionately larger and all be well rooted.

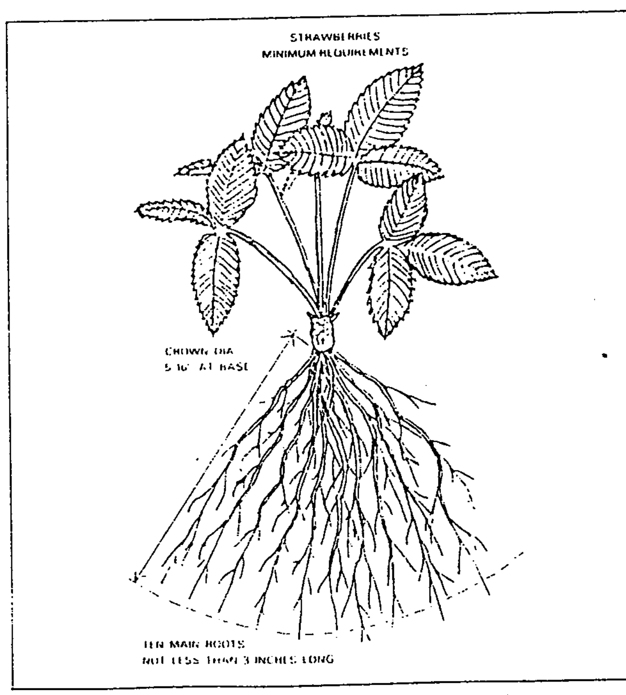
GRADE 2 YR. NO. 2

Same specifications as 1 Yr. No. 1.

8.7 STRAWBERRY PLANTS

MINIMUM GRADE

There shall be at least ten (10) main roots, not less than three (3) inches long, and a minimum crown diameter of 5/16 in. measured at the base.



8.6 ASPARAGUS CROWNS

1 YR. NO. 1
Shall not weigh less than sixty (60) pounds per thousand. Fifty (50%) per cent of the root system shall exceed five (5 in.) inches in length.

2 YR. NO. 1
Shall not weigh less than one hundred twenty (120) pounds per thousand plants. Fifty (50%) per cent of the root system shall exceed seven (7 in.) inches in length.

2 YR. NO. 2
Shall not weigh less than sixty (60) pounds per thousand. Fifty (50%) per cent of the root system shall exceed five (5 in.) inches in length.

3 AND 4 YR. NO. 1 — Super Size, Bearing Age.
Shall not weigh less than two hundred (200) pounds per thousand. Fifty (50%) per cent of the root system shall exceed ten (10 in.) inches in length.

9 LINING OUT STOCK

9.1 GENERAL
Lining out stock shall include all plant material coming from propagating houses, beds or frames and young material of suitable size to plant out in a nursery.

9.2 DESIGNATION
Age — Should be given by number of years since propagated or in the case of seedlings, since growth started.
Transplanted — The number of times transplanted to be represented by using for each transplanting the letter "T."
Seedling — Stock to be represented by the letter "S."
Cuttings — To be represented by the letter "C."
Grafted — Stock to be represented by the letter "G."
Size — Should be given in accordance with the intervals recommended for each plant class.
EXAMPLE: Koster Spruce G. 6-8 in., 4 yr. TT means Koster Spruce graft, 6 to 8 inches high, 4 years old and twice transplanted.
Pot Grown or Container Grown — Lining out stock supplied in pots or similar containers shall be thrifty, well-branched plants, well established in the containers.

9.3 SIZE DESIGNATION
In grading use 2 inch intervals up to 12 in.; 3 inch intervals up to 24 in.; 6 inch intervals for larger sizes.

9.4 RECOMMENDATIONS—EVERGREEN LINING OUT STOCK
Evergreens should be transplanted frequently enough to create a good root system, which will insure a minimum of transplanting loss, and to give the top room enough to start the branch framework properly, making a well-shaped specimen when placed in the nursery row.

In order to produce a fibrous root system we recommend that in species such as Firs, Pines and similar sorts, which normally make a few coarse roots, that they be transplanted every two or three years, and that species such as Arborvitae and Chamaecyparis be transplanted every three to four years as they naturally make better roots.

Broad leaved evergreen species such as Pyracantha lalandi, which normally make a few coarse roots, should be transplanted every year, while those producing a good system of fibrous roots may be transplanted every second year only.

Trimming is also necessary to insure a proper foundation for good shape in the finished plant, although frequent transplanting will usually avoid the necessity of severe trimming.

10 SEEDLING TREES AND SHRUBS

10.1 GENERAL

Forest, game refuge, erosion control, shelterbelt, or farm woodlot plantings, under natural conditions shall come under the following classifications. Actual conditions of soil, climate, and environment will necessarily govern the minimum size for a particular species that is required.

Tolerance of not more than 10% under grade should be accepted so long as it is not intentional and the ones under grade are close to the grade required.

10.2 DECIDUOUS OR HARDWOODS

When caliper is important measurements are taken **at** root collar or ground line.

Caliper in inches	Min. height in inches	Min. root length
1/4 in. and up	12 in.	10 in.
3/16-1/4 in.	10 in.	10 in.
1/8-3/16 in.	8 in.	8 in.
1/16-1/8 in.	6 in.	8 in.

Tops or roots will not be trimmed unless specified by grower or requested by purchaser.

When height is important measurements are taken **from** root collar or ground line.

Height in inches	Min. caliper in inches	Min. root length
24-36 in.	1/4 in.	12 in.
18-24 in.	3/16 in.	10 in.
12-18 in.	1/8 in.	10 in.
6-12 in.	1/16 in.	8 in.

Suggested for commercial nurseries furnishing or purchasing stock for the retail trade, and still comply with demands for calipered stock.

It should be understood that when heights are to govern that caliper specification is minimum and when caliper is to govern, the height specification is minimum.

10.3 CONIFERS—EVERGREENS

Height in inches	Min. caliper in inches
12-15 in.	3/16 in.
9-12 in.	1/8 in.
6-9 in.	1/16 in.

Age is not important when height or caliper is specified; however it may be used in listings or demanded by purchaser.

KEY for use in indicating seedling, root pruned, or transplants:

S — for seedling
RP — for root pruned (should not be root pruned deeper than 6 inches when applying to conifers)
T — one T for each time transplanted.

General — All plants are to have well developed root systems, to be free of insects and diseases as well as mechanical injuries, and in all respects be suitable for field planting. All conifers must have dormant buds (except in the south) and secondary needles.

At the option of the purchaser other special restrictions may be specified.

11 BULBS, CORMS AND TUBERS

11.1 GENERAL

Bulbs and corms are generally sold under grade names such as forcing size, top-size, large, etc. In the case of Narcissus and Daffodils, the designations of "double nose" to indicate a split bulb with probably two flower buds and "rounds" are used.

With some groups, for example Hyacinths, the grade names indicate usage such as exhibition and forcing sizes and sizes more suitable for outdoor bedding purposes.

Some grade measurements have normally been given in centimeters of circumference, since this measurement allows closer grading. This system is in vogue and is generally accepted in the trade for the smaller sized bulbs such as Crocus and Grape Hyacinth, while for larger and particularly for the flat type corms, inches in diameter is the generally accepted measurement: for example, Gladioli, Tuberous Begonias and Caladiums.

For such items as Peonies and Bleeding Heart and Cannas, the number of "eyes" or buds on the tuber is designated.

The following grades conform in substance to generally accepted trade usage. Both grade names and sizes in inches or centimeters should be given; size in inches or centimeters must be designated.

Offers of bulbs, corms and tubers (except Peony divisions) which cannot reasonably be expected to bloom in the season after planting should not be made to the public. If they are, then they should be clearly indicated as "non-blooming" sizes for naturalization or other plantings for which "non-blooming" sizes might be acceptable.

11.2 TULIPS

Designated by centimeters or inches of circumference.

Top size (12 cm. and up) . . . . 4-3/4" up in circumference
Large (11-12 cm.) . . . . 4-3/8"—4-3/4" circumference
Medium (10-11 cm.) . . . . 4"—4-3/8" circumference
Small (9-10 cm.) . . . . 3-5/8"—4" circumference

Note: Some botanical and species Tulips are smaller than above-designated sizes. Bulbs of botanical and species tulips should be so identified and sizes given.

11.3 HYACINTHS

Designated by centimeters or inches of circumference.

Top Exhibition Forcing Size
(19 cm. and up) . . . . 7-5/8" up in circumference
Large Exhibition Forcing Size
(18-19 cm.) . . . . 7-1/4"—7-5/8" circumference
Medium Exhibition Forcing Size
(17-18 cm.) . . . . 6-3/4"—7-1/4" circumference
Top Bedding or Garden Size
(16-17 cm.) . . . . 6-3/8"—6-3/4" circumference
Large Bedding or Garden Size
(15-16 cm.) . . . . 6"—6-3/8" circumference
Medium Bedding, Miniature,
or Garden Size (14-15 cm.) . . . 5-1/2"—6" circumference

11.4 GRAPE HYACINTHS

Designated by centimeters or inches of circumference.

Top Size . . . . 9-11 cm. and up in circumference
Large Size . . . . 8-9 cm. circumference
Medium Size . . . . 7-8 cm. circumference

11.5 CROCUS

Designated by centimeters or inches of circumference.

Top Size (9 cm. and up) . . . . 3-5/8" up in circumference
Large (8-9 cm.) . . . . 3-1/8"—3-5/8" circumference
Medium (7-8 cm.) . . . . 2-3/4"—3-1/8" circumference
Small (6-7 cm.) . . . . 2"—2-3/4" circumference

11.6 NARCISSUS AND DAFFODILS

Designated by centimeters or inches of circumference.

Top Size Round Large Size Round Medium Size Round	"Round means single nosed bulbs which are fairly circular in cross-section and which show evidence of producing one flower. Slabs are not permitted in this grade.
Top Size Double Nose Large Size Double Nose Medium Size Double Nose	"Double Nose" means bulbs that show evidence of producing two or more flowers. Due to double character of bulb, circumference measurements are variable.

There are certain varieties that normally have smaller bulbs than others. Until size grades are established, name grade designations as indicated and accepted by the trade (as bulbs are purchased) should be used.

11.7 NARCISSUS — PAPER WHITE

Paper White. (A type of bulb that normally is a smaller bulb than other varieties and consequently is listed separately.)

Designated by centimeters or inches of circumference.

Top Size (16 cm. up) . . . . 6-3/8" up in circumference
Large (15-16 cm.) . . . . 6"—6-3/8" circumference
Medium (14-15 cm.) . . . . 5-1/2"—6" circumference
Small (12-14 cm.) . . . . 4-3/4"—5-1/2" circumference

11.8 GLADIOLI

Designated by inches in diameter according to Fair Trade Practice Rules adopted by Gladiolus Growers as follows:

Jumbo		Over 2" in diameter
Large	No. 1	1-1/2"—2" diameter
	No. 2	1-1/4"—1-1/2" diameter
Medium	No. 3	1"—1-1/4" diameter
	No. 4	3/4"—1" diameter
Small	No. 5	1/2"—3/4" diameter
	No. 6	3/8"—1/2" diameter
No grade name	No. 7	under 3/8" diameter

11.9 AMARYLLIS

Designated by inches in diameter

Fancy	3-1/2" up in diameter
Top Size	3-1/4"—3-1/2" diameter
Large	3"—3-1/4" diameter
Medium	2-3/4"—3" diameter
Small	2-1/4"—2-3/4" diameter

Under 2-1/4" not acceptable

11.10 LILIES

(Regal and Easter.)
Designated by inches of circumference.

Giant	10" up circumference
Fancy	9-10" circumference
Extra Large	8-9" circumference
Large	7-8" circumference
Standard	6-7" circumference
Medium	5-6" circumference

11.11 CALADIUM

(Fancy-leaved.)
Designated by inches in diameter.

Giant	3-1/2" up in diameter
Large	2-1/2"—3-1/2" diameter
Standard	2"—2-1/2" diameter
Medium	1-1/2"—2" diameter
Small	1"—1-1/2" diameter

11.12 TUBEROUS BEGONIAS AND GLOXINIAS

Designated by inches in diameter.

Giant Size	2-1/2" and up in diameter
Extra Large	2"—2-1/2" diameter
Large	1-1/2"—2" diameter
Medium	1-1/4"—1-1/2" diameter
Small	1"—1-1/4" diameter

11.13 TUBEROSES, CALLAS AND OTHER MISCELLANEOUS BULBS

Designated in centimeters or inches in diameter or circumference as generally accepted trade practice may dictate.

11.13.1 TUBEROSES

Top Size	4"—6" circumference
First Size	3"—4" circumference

11.13.2 CALLAS

Top Size	2-1/2" and up in diameter
Large	2"—2-1/2" diameter
Medium	1-1/2"—2" diameter
Small	1-1/4"—1-1/2" diameter

11.13.3 RANUNCULUS

Giant Size	1" and up in diameter
Extra Large	7/8"—1" diameter
Large	3/4"—7/8" diameter
Medium	5/8"—3/4" diameter
Small	1/2"—5/8" diameter

11.13.4 FREESIA

Extra Large	7/8" and up in diameter
Large	3/4"—7/8" diameter
Medium	5/8"—3/4" diameter
Small	1/2"—5/8" diameter

11.13.5 ANEMONES

Extra Large	7/8" and up in diameter
Large	3/4"—7/8" diameter
Medium	5/8"—3/4" diameter
Small	1/2"—5/8" diameter

11.14 PEONIES AND BLEEDING HEART

Number of "eyes" or "buds" per division to be indicated.

Select	5-7 "eye" divisions
Standard	3-5 "eye" divisions
Small	2-3 "eye" divisions

11.15 CANNAS

Number of "eyes" or "buds" per root to be indicated: for example 2-3 "eye" roots. Any root with less than 2 "eyes" not to be offered the public — suitable for growing on in nursery, or for potting or bedding purposes.

11.16 DAHLIAS

Due to nature of divisions from different varieties no size designations can be listed. Each division must have a portion of live crown and at least 1 "eye" or "bud."

12 CHRISTMAS TREE STANDARDS

The standard herewith shall conform to the standards promulgated by the United States Department of Agriculture, effective Jun 15, 1962, and as thereafter may be revised. These standards are based on the factors of density, taper, balance, foliage and deformities and are classified as U.S. Premium, U.S. No. 1 or U.S. Choice, U.S. No. 2 or U.S. Standard, and Culls. Copies of these standards are available from the Consumer and Marketing Service, U.S. Department of Agriculture, Washington, D.C. 20250.

SECTION 02480

LANDSCAPING - TURF ESTABLISHMENT

PART 1 - GENERAL

1.01 DESCRIPTION

A. Work specified in this section includes:
   1. Topsoiling
   2. Fertilizing
   3. Seeding
   4. Sodding
   5. Mulching
   6. Erosion Mat

1.02 REFERENCE STANDARDS

A. Association of Official Seed Analysis (AOSA):
   1. Rules for testing seed.

B. American Association of State Highway and Transportation Officials (AASHTO):
   1. AASHTO M140 Emulsified Asphalt

1.03 SUBMITTALS

A. Fertilizer
   1. Furnish certification from supplier attesting to:
      a. Brand name, chemical analysis, and guarantee of analysis.

B. Seed
   1. Furnish certification of conformance with AOSA "Rules for Testing Seed" and attest to:
      a. Mix, age, weed content, purity, and germination.

C. Sod
   1. Furnish certification that sod complies with all State and Federal regulations with respect to inspection for plant diseases and insect infestation.
   2. Furnish certification of origin and date of cut.

D. Mulch Material
   1. Furnish sample of mulch material when requested by Owner's representative.

E. Erosion Mat
   1. Furnish sample of erosion mat material along with a certification of its physical properties.

PART 2 - PRODUCTS

2.01 TOPSOIL

A. Shall meet the requirements of Soil Class F-1 (Salvaged Topsoil) or Soil Class F-2 (Borrow Topsoil) in accordance to Section: Soils and Aggregates.

2.02 FERTILIZER AND AGRICULTURAL LIMESTONE

A. Fertilizer shall meet the recommendations of the soil analysis report required by Section: Soils and Aggregates.

B. Agricultural Limestone
   1. Shall conform to Soil Class J-1 as defined in Section: Soils and Aggregates.

2.03 SEED

A. Conform with the requirements of the governing authority for seeding and for restrictions on noxious weed seed.

B. Seed mixture shall be composed of seeds of the purity, germination, and proportion by weight as follows:

TABLE OF SEED MIXTURES

	Seeds		Mixtures					
Species	Min. % Purity	Min. % Germination	% in No. 1	% in No. 2	% in No. 3	% in No. 4	% in No. 5	% in No. 6
Kentucky 31 Fescue	97	85	--	--	65	--	--	
Kentucky Bluegrass	85	80	45	20	15	60	--	
Creeping Red-Fescue	97	80	35	55	15	30	--	
Perennial Rye-Grass	95	90	5	10	5	10	--	
White Clover Empire	95	90	15	--	--	--	--	
Birdsfoot Trefoil	95	80	--	15	--	--	50	
Crownvetch	95	70	--	--	--	--	50	
Reed Canary Grass	92	65	--	--	--	--	--	65
Red Top	75	78	--	--	--	--	--	20
Timothy	92	84	--	--	--	--	--	15

C. Temporary Nurse Crop
   1. When required the Contractor shall furnish one of the following seed mixtures:

Species	Min. % Purity	Min. % Germ.	Lbs. per Acre
Oats	98	90	80
Rye	98	85	100

2.04 SOD

A. The sod shall consist of a dense, well rooted growth of permanent and desirable grasses, indigenous to the general locality where it is to be used.

B. Sod shall meet the following general requirements:
   1. Free from weeds and undesirable grasses.
   2. Grass length of 2 inches.
   3. Cut in uniform strips 18" x 72".
   4. Uniform thickness of 1-1/2 inch or more.
   5. Adequately watered to prevent crumbling, breaking or tearing during handling and placement.

2.05 MULCH

A. Mulch shall consist of straw, hay, marsh hay or wood chips which are free of noxious weeds and other objectionable foreign matter.
   1. If wood chips are used, the mulch area shall be treated with one (1) pound of available nitrogen per 1000 square feet.

B. Mulch binder shall conform to one of the following:
   1. Emulsified asphalt shall meet the requirements for Type SS-1 AASHTO M140.
   2. Terra Tack I, or equal.

2.06 EROSION MATS

A. Jute fabric shall meet the following general requirements:
   1. Uniform, open weave of single jute yarn.
   2. Twisted construction having an average twist of not less than one and one-half turns per inch.
   3. Furnished in rolled strips 48 inches wide with a minimum of 78 wrapped ends.
   4. Fabric shall have a minimum of 41 weft yarns per linear yard of length.
   5. Weight of fabric shall be a minimum of 92 lbs. per 100 square yards.
   6. Non-toxic to vegetation.
   7. Smolder resistant.

B. Wood fiber blanket shall meet the following general requirements:
   1. Uniform web of interlocking wood excelsior fibers.
   2. Uniform thickness.
   3. Weight - 78 pounds per 80 square yards.

4. Have net backing on one side as follows:
   a. Mesh size not exceeding 1-1/2 inches by 3 inches.
   b. Woven of twisted paper, cotton cord or biodegradable plastic.
5. Non-toxic to vegetation.

C. Permanent Geomats:
   1. Consist of a tough, flexible matting made of a high density polyethylene or similar material.
   2. Ultra-violet resistant.
   3. Have a minimum thickness of .4 inch (1.0 cm).
   4. Non-toxic to vegetation.
   5. Contain no petroleum solvents or other agents toxic to plant or animal life.

D. Staples
   1. Staples for anchoring erosion mat shall meet the following minimum requirements:
      a. U-shaped.
      b. No. 11 gage or larger diameter steel wire.
      c. Width of one to two inches.
      d. Length.
         1) Not less than six (6) inches for firm soil.
         2) Not less than twelve (12) inches for soft or loose soils.
         3) Not less than eight (8) inches where erosion mat is placed over sod.

PART 3 - EXECUTION

3.01 TOPSOILING

A. Topsoil in areas to be seeded or sodded:
   1. Minimum of 4 inches when in a compacted or settled condition.
   2. All areas where a lawn type turf is established shall be compacted by rolling. All other areas may be allowed to settle.

3.02 FERTILIZING AND LIMING

A. Fertilize and lime all areas to be seeded or sodded.

B. Application rate shall conform to soil analysis report.

C. Incorporation shall be performed by light discing or harrowing during seeding operation.

3.03 SEEDING

A. Selection of seed mixtures, rate of seeding and intended use of the mixtures will be as follows:

Seed Mixture	Rate of Seeding (Lbs. per 1000 sq. ft.)	Intended Use
No. 1	1-1/2	Average loam or heavy clay soils All ditches, inslopes grass areas.
No. 2	2	Light, sandy or gravelly soils. All ditches, inslopes.
No. 3	3	In rural areas on cut and fill slopes exceeding 6 to 8 feet.
No. 4	2	In urban area or other areas where a lawn type turf is desired.
No. 5	1/2	Critical area stabilization. May be used in conjunction with mixture NO. 1 and No. 2 on steep slopes.
No. 6	1-1/2	Poorly drained soils. Critical area stabilization (usually not mowed).

B. Seeding period shall be as recommended by the seed supplier.

C. Seed Bed Preparation
   1. Grade, trim, shape and smooth topsoil to required grade and section.
   2. Remove all cobbles (3" or larger), clay lumps, and other debris.
   3. Disc, harrow, drag or handwork topsoil to a minimum depth of 3 inches.

D. Seeding
   1. Utilize a machine or combination of machinery which will produce the following:
      a. Apply seed uniformly at the rate specified.
      b. Cover seed with approximately 1/4 inch of topsoil.
      c. Roll lightly.
      d. Apply seed at right angles to surface drainage.

3.04 SODDING

A. Preparation of areas to be sodded.
   1. Topsoil and fertilize areas to be sodded.
   2. Prepare sod bed as in 3.01 A.

B. Placing Sod
   1. Moisten topsoil to loosened depth of 3 inches.
   2. Place sod within 24 hours after initially cut.
   3. Laying sod strips.
      a. Lay sod so abutting end joints are not continuous.
      b. Sod strips shall abut snugly against each other.
      c. Sod shall be level with adjoining turf or grade.
      d. Water and roll or lightly tamp sod immediately after placement.
      e. At the limits of the sodded area, end strips shall be staggered.
      f. At the end of all sod strips, turn sod into soil, cover with topsoil, and compact.
   4. Laying sod on slopes and in waterways.
      a. In waterways, place sod with longer dimension perpendicular to water flow.
      b. On slopes, place sod with longer dimension parallel to the contours of the ground.

C. Staking Sod
   1. Stake sod in all waterways and on all slopes steeper than one foot vertical to four feet horizontal.
   2. Stakes shall be wood lath minimum of 12 inches long.
   3. Place stakes on top edge of sod strip and drive plumb thru sod to point approximately flush with sod.
   4. Space stakes 18 inches to 36 inches apart depending on the nature of the soil and steepness of the slope.

3.05 MULCHING

A. Complete mulching as follows:
   1. Within 48 hours after seeding has been completed.
   2. Place all mulch uniformly to a loose depth of 1 to 1-1/2 inches (2 to 3 tons per acre).
   3. Mulching operation shall begin at the top of slopes and proceed downward.

B. Mulching shall be secured using one of the following methods:
   1. Method "A"
      a. Secure mulch with heavy twin or netting.
         1) Twine to be fastened with pegs or staples to form a grid of six to ten foot spacing.
   2. Method "B"
      a. Apply emulsified asphalt at the rate of 200 to 300 gallons per acre.
      b. Machinery used for placing mulch and emulsified asphalt shall produce a spotty tack sufficient to hold together and retain in place the deposited mulch material.

3. Method "C"
   a. Anchor mulch in soil by means of a mulch tiller.
   b. Mulch shall be impressed in the topsoil to a depth of 1-1/2 to 2-1/2 inches in one pass of the tiller.

3.06 EROSION MAT

A. Erosion Mat - Installation:
   1. Install erosion mat at locations designated on the plans within 48 hours after completion of seeding.
   2. Use only jute fabric over sodded areas.
   3. All stones, soil clods, roots, sticks, and other foreign material shall be removed prior to placing the mat.

B. Installation of Jute Fabric Wood Fiber Blanket (Excelsior):
   1. Matting strips to be laid in the direction of surface water flow.
   2. Adjacent strips shall overlap at least 4 inches.
   3. Mat strip ends shall overlap at least 10 inches.
   4. Wood fiber blanket shall be installed with netting on top.
   5. Bury the upgrade end of each strip of fabric at least eight inches in a vertical slot cut in the soil and firmly tamping soil against fabric as follows:
      a. For ditch grades of 4% or less, construct vertical slots every 50 feet.
      b. For ditch grades of 4% or more, construct vertical slots every 25 feet.
   6. Form terminal fold at the bottom end of the erosion mat by folding under approximately 4 inches of mat and stapling it to the ground.
   7. Install staples as follows:
      a. Vertically until tops are flush with the soil.
      b. Space staples at three (3) foot centers along overlap at mat edges and alternate at three foot centers through mat centers.
      c. Space staples at ten (10) inch centers at mat ends and junction slots.

C. Installation of Permanent Geomats:
   1. Geomats shall be installed in accordance with the procedure recommended by the manufacturer and be suitable for the intended use.

3.07 APPLICATION

A. Apply landscaping and turf establishment procedures as follows:
   1. Areas with less than 4 to 1 slope:
      a. Topsoil.
      b. Seed.
      c. Fertilize.
      d. Mulch and mulch binder.
   2. Lawns with 4 to 1 or greater slopes: Sod.
   3. Rural and unmowed areas with 4 to 1 slopes to 3 to 1:
      a. Topsoil.
      b. Seed.
      c. Fertilize.
      d. Stabilize with wood fiber erosion mat.

4. Rural and unmowed areas with 3 to 1 slopes or greater:
    a. Topsoil.
    b. Seed.
    c. Fertilize.
    d. Stabilize with permanent geomat.

3.08 MAINTENANCE

A. Maintain all seeded and sodded areas until all the following conditions are met.
    1. Seeding: Establish a good stand of grass (uniform in density and color) satisfactory to Owner.
    2. Sodding: Establish a root system into sod bed.
    3. Capable of resisting erosion.

B. Watering of turf shall be included in maintenance.

- END OF SECTION -

SECTION 2490

LANDSCAPING - TREES, PLANTS, AND GROUND COVER

PART 1 - GENERAL

1.01 Description

A. Work included: Provide trees, plants, and ground cover as indicated on the Drawings, as specified herein, and as needed for a complete and proper installation.

1.02 Quality Assurance

A. Use adequate numbers of skilled workmen who are throughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

B. Standards:
   1. Plants and planting material: Meet or exceed the specifications of Federal, State and county laws requiring inspection for plant disease and insect control.
   2. Quality and size: Comply with current edition of "Horticultural Standards" for number one nursery stock as adopted by American Association of Nurserymen.
   3. All Plants:
      a. True to name, with one of each bundle or lot tagged with the name and size of the plants in accordance with standards of practice of American Association of Nurserymen.
      b. In all cases, botanical names take precedence over common names.

1.03 Submittals

A. Product data: Within 60 calendar days after the Contractor has received the Owner's Notice to Proceed, submit:
   1. Materials list of items proposed to be provided under this Section;
   2. Complete data on source, size, and quality.
   3. Sufficient data to demonstrate compliance with the specified requirements.

B. Upon completion of the work of this Section, and as a condition of its acceptance, deliver to the Landscape Architect two copies of a Maintenance Manual compiled in accordance with the scope of work.

C. Product Handling
Immediately remove from the site, plants which are not true to name, and materials which do not comply with the specified requirements, and promptly replace with plants and materials meeting the specified requirements.

PART 2 - PRODUCTS

2.01 Fertilizer

Provide commercial balanced 11-8-4 fertilizer.

2.02 Soil Amendment

Provide composted cow or sheep manure.

2.03 Mulch

Provide locally produced shredded mill-run chips of bark.

2.04 Tree Stakes

Unless otherwise indicated on the Drawings, provide Redwood stakes, Construction grade, rough sawn, 2" x 2" x 2' long.

2.05 Grass Seed

A. General: Provide grass seed which is:
   1. Free from noxious week seeds, and recleaned;
   2. Grade A recent crop seed;
   3. Treated with appropriate fungicide at time of mixing;
   4. Delivered to the site in sealed containers with dealer's guaranteed analysis.

B. Proportions by weight:
   1. Merion bluegrass: 50%
   2. Newport bluegrass: 50%

2.06 Plant Materials

Provide the plant materials shown on the schedule in the Drawings.

2.07 Other Materials

Provide other materials, not specifically described but required for a complete and proper installation, as selected by the Contractor subject to the approval of the Architect.

PART 3 - EXECUTION

3.01 Surface Conditions

Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.02 Spreading Topsoil

A. Finish grading will be performed under Section 02470.

B. Upon completion of finish grading, perform fine grading required in planting area, using soil obtained from the site.

C. Raised planter beds:
   1. Backfill with a mixture consisting of three part topsoil and one part specified soil amendment, by volume.
   2. Place the backfill mixture in layers not exceeding 8" uncompacted thickness.
   3. Compact each layer by thorough saturation with water to prevent future settlement.

3.03 Planting Trees and Shrubs

A. General:
   1. Plant nursery stock immediately upon delivery to the site and approval by the Landscape Architect except that, if this is not feasible, heel-in all bare root and balled materials with damp soil and protect from sun and wind.
   2. Regularly water nursery stock in containers, and place them in a cool area protected from the sun and drying winds.

B. Excavating:
   1. For shrubs in one gallon containers, dig a hole 12" in diameter and 12" deep.
   2. For shrubs and trees in five gallon containers, dig a hole 20" in diameter and 18" deep.
   3. For trees in 15 gallon containers, dig a hole 30" in diameter and 30" deep.
   4. At holes more than 12" deep, probe by hand to determine if mechanical auger will hit any in-place utilities.

C. Planting:
   1. Fill holes with backfill mixture consisting of three parts soil taken from the hole and one part specified soil amendment, by volume.
   2. Fill to proper height to receive the plant, and throughly tamp the mixture before setting the plant.
   3. Set plant in upright position in the center of the hole, and compact the backfill mixture around the ball or roots.
   4. Throughly water each plant when the hole is 2/3 full.
   5. After watering, tamp the soil in place until the surface of the backfill is level with the surrounding area and the crown of the plant is at the finished grade of the surrounding area.
   6. Build up a temporary watering basin around the base of each tree and shrub, unless otherwise directed by the Architect, except no basins around trees and shrubs, in turf area or in raised planter beds.

D. Apply the specified mulch to a depth of 3", evenly spread over the entire area of each soil basin.

3.04 Planting Ground Cover

A. Rake existing soil smooth and free from soil lumps, rocks, sticks, and other deleterious material.

B. Planting:
   1. Space the ground cover plants evenly as indicated ont he Drawings, staggering the spaces around shrubs and trees as well as the open areas.
   2. Plant only in soil that is moist but friable, never wet or soggy.
   3. In case of planting in the open on hot days, shorten the time between planting and watering.

3.05 Staking

Stake trees, using one stake per tree with two tree ties per stake, and driving stakes into the ground at least tow feet.

3.06 Inspection

In addition to normal progress observations, schedule and conduct the following formal inspections, giving the Landscape Architect at least 24 hours of advance notice of readiness for inspection:
1. Inspection of plants in containers prior to planting.
2. Inspection of plant locations, to verify compliance with the Drawings.
3. Final inspection after completion of planting:
   a. Schedule this inspection sufficiently in advance, and in cooperation with the Landscape Architect, so final inspection may be conducted within 24 hours after completion of planting.
4. Final inspection at the end of the maintenance period, provided that previous deficiencies have been corrected.

3.07 Maintenance

A. Maintain planting, starting with the planting oeprations and continuing for 30 calendar days after planting in complete and approved by the Landscape Architect.

B. Work included:
   1. Watering, weeding, cultivating, spraying, and pruning necessary to keep the plant materials in a healthy growing condition and to keep the planted areas neat and attractive throughout the maintenance period.
   2. Provide equipment and means for proper application of water to those planted areas not equipped with an irrigation system.
   3. Protect planted areas against damage, including erosion and trespassing, by providing and maintaining proper safeguards.

C. Replacements:
   1. At the end of the maintenance period, all plant material shall be in a healthy growing condition.
   2. During the maintenance period, should the appearance of any plant indicate weakness and probability of dying, immediately replace that plant with a new and healthy plant of the same type land size without additional cost to the Owner.
   3. Replacements required because of vandalism or other causes beyond the control of the Contractor are not part of the Contract.

Extension of maintenance period:
   1. Continue the maintenance period at no additional cost to the owner until previously noted deflciencies have been corrected, at which time the final inspection will be made.

- END OF SECTION -

APPENDIX N

Water Budget Calculations

Infiltration Calculations

Data Sources

Data	Source
Monthly Air Temperature	N.O.A.A. 1960 thru 1988, Weyerhaeuser, Wi
Monthly Precipitation	N.O.A.A. 1960 thru 1988, Weyerhaeuser, Wi
Conversion and Computation Tables	Thornthwaite and Mather, 1975
Runoff Coefficients	U.S. EPA, 1975 Soil Conservation, Hudson, N., 1971
Water Holding Capacity of Soil	U.S. EPA, 1975
Evaporation from Bare Soils	U.S. EPA, 1975

I. <u>Type II Stockpile - Assumptions</u>:

A. The 1977 monthly temperature and precipitation N.O.A.A. data for Weyerhaeuser, WI were used to represent wet precipitation conditions.

B. The 1976 monthly temperature and precipitation N.O.A.A. data for Weyerhaeuser, WI were used to represent dry precipitation conditions.

C. The average of the 1960 through 1988 monthly temperature and precipitation N.O.A.A. data for Weyerhaeuser, WI was used to represent average precipitation conditions.

D. The Type II stockpile consists of 27 acres.

E. After removal of the stored material the stockpile area will be restored to approximate preconstruction conditions. Therefore, the preconstruction and post construction water budget conditions are the same. The existing ground slope is approximately 2%.

F. The Type II stockpile has a life of approximately 6.3 years. An additional 0.5 years was considered in the calculations to address the period of time over which site construction will be completed but no Type II material will be placed.

G. The stockpile will be filled in two phases.

-Entire stockpile area (27 acres) is open from October 1990 to April 1991 before filling with waste rock begins.

-Filling in Phase I begins April 1991.

-Filling in Phase II begins in January 1994.

-Site restoration is completed June 1997.

H. Runoff and evaporation from bare soils are approximately 75% of the total precipitation (U.S. EPA, 1975).

I. Flat slope was assumed for during construction calculations. Assumption is reasonable given the large ratio of flat area to steep area on the site.

II. Type II Stockpile - Infiltration Calculations

1. Preconstruction and Post Construction
   2% slope

1a. Wet Conditions - Infiltration

$$27 \text{ Acres} \times \frac{16.27 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

$$= \frac{11{,}927{,}800 \text{ gal}}{\text{yr}}$$

1b. Dry Conditions - Infiltration

$$27 \text{ Acres} \times \frac{7.9 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

$$= \frac{5{,}791{,}600 \text{ gal}}{\text{yr}}$$

1c. Average Conditions - Infiltration

$$27 \text{ Acres} \times \frac{10.98 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

$$= \frac{8{,}049{,}600 \text{ gal}}{\text{yr}}$$

2. During Construction Infiltration Calculation

2a. Wet Conditions

precip = $\frac{45.62 \text{ in}}{\text{yr}}$ Infiltration $\frac{45.6 \text{ in}}{\text{yr}} \times 25\% = \frac{11.40 \text{ in}}{\text{yr}}$

Area Open Before Filling

$.5 \text{ yr} \times 27 \text{ AC} \times \frac{11.40 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$

$= \underline{4{,}178{,}800 \text{ gal}}$

Phase I Filling of Waste Rock

$2.75 \text{ yrs} \times 15.53 \text{ AC} \times \frac{11.40 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$

$= \underline{13{,}219{,}600 \text{ gal}}$

Phase II Open No Filling

$2.75 \text{ yrs} \times 11.47 \text{ AC} \times \frac{11.40 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$

$= \underline{9{,}763{,}600 \text{ gal}}$

Phase I & II Filling and Removal of Waste Rock

$3.55 \text{ yrs} \times 27 \text{ AC} \times \frac{11.40 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$

$= \underline{29{,}669{,}200 \text{ gal}}$

2b. Dry Conditions

precip = $\frac{18.06 \text{ in}}{\text{yr}}$ Infiltration $\frac{18.06 \text{ in}}{\text{yr}} \times 25\% = \frac{4.51 \text{ in}}{\text{yr}}$

Area Open Before Filling

$.5 \text{ yr} \times 27 \text{ AC} \times \frac{4.51 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$

$= \underline{1{,}653{,}200 \text{ gal}}$

Phase I Filling of Waste Rock

$$2.75 \text{ yrs} \times 15.53 \text{ AC} \times \frac{4.51 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

= 5,229,800 gal

Phase II Open No Filling

$$2.75 \text{ yrs} \times 11.47 \text{ AC} \times \frac{4.51 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

= 3,862,600 gal

Phase I & II Filling and Removal of Waste Rock

$$3.55 \text{ yrs} \times 27 \text{ AC} \times \frac{4.51 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

= 11,737,500 gal

2c. Average Conditions
precip = $\frac{34.03 \text{ in}}{\text{yr}}$ Infiltration $\frac{34.03 \text{ in}}{\text{yr}} \times 25\% = \frac{8.51 \text{ in}}{\text{yr}}$

Area Open Before Filling

$$.5 \text{ yr} \times 27 \text{ AC} \times \frac{8.51 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

= 3,119,400 gal

Phase I Filling of Waste Rock

$$2.75 \text{ yrs} \times 15.53 \text{ AC} \times \frac{8.51 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

= 9,868,300 gal

Phase II Open No Filling

$$2.75 \text{ yrs} \times 11.47 \text{ AC} \times \frac{8.51 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

= 7,288,400 gal

Phase I & II Filling and Removal of Waste Rock

$$3.55 \text{ yrs} \times 27 \text{ AC} \times \frac{8.51 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

= 22,147,800 gal

III. Type I Stockpile - Assumptions:

A. The 1977 monthly temperature and precipitation N.O.A.A. data for Weyerhaeuser, WI were used to represent wet precipitation conditions.

B. The 1976 monthly temperature and precipitation N.O.A.A. data for Weyerhaeuser, WI were used to represent dry precipitation conditions.

C. The average of the 1960 through 1988 monthly temperature and precipitation N.O.A.A. data for Weyerhaeuser, WI was used to represent average precipitation conditions.

D. The Type I stockpile consists of 40 acres.

E. After removal of the stored material the stockpile area will be restored to approximate preconstruction conditions. Therefore, the preconstruction and post construction water budget conditions are the same. The existing ground slopes are approximately 2% and 4%.

F. The Type I stockpile has a life of approximately 7.5 years.

G. The stockpile will be filled in one phase. Therefore, it is assumed the total 40 acres is open for the site life.

H. Runoff and evaporation from bare soils is approximately 75% of the total precipitation (U.S. EPA, 1975).

I. Flat slope was assumed for during construction calculations. Assumption is reasonable given the large ratio of flat area to steep area on the site.

IV. Type I Stockpile - Infiltration Calculations

1. Preconstruction and Post Construction
   2% and 4% slopes

   1a. Wet Conditions - Infiltration

   2% Slope (~10 AC)

$$10 \text{ Acres} \times \frac{16.27 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

$$= \frac{4,417,700 \text{ gal}}{\text{yr}}$$

   4% Slope (~30 AC)

$$30 \text{ AC} \times \frac{14.34 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

$$= \frac{11,681,000 \text{ gal}}{\text{yr}}$$

$$\text{Total} = \frac{16,098,700 \text{ gal}}{\text{yr}}$$

   1b. Dry Conditions - Infiltration

   2% Slope (~10 AC)

$$10 \text{ AC} \times \frac{7.9 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

$$= \frac{2,145,000 \text{ gal}}{\text{yr}}$$

   4% Slope (~30 AC)

$$30 \text{ AC} \times \frac{7.76 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

$$= \frac{6,321,100 \text{ gal}}{\text{yr}}$$

$$\text{Total} = \frac{8,466,100 \text{ gal}}{\text{yr}}$$

1c. Average Conditions - Infiltration

2% Slope (~10 AC)

$$10 \text{ AC} \times \frac{10.98 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

$$= \frac{2{,}981{,}300 \text{ gal}}{\text{yr}}$$

4% Slope (~30 AC)

$$30 \text{ AC} \times \frac{10.98 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

$$= \frac{8{,}944{,}000 \text{ gal}}{\text{yr}}$$

$$\text{Total} = \frac{11{,}925{,}300 \text{ gal}}{\text{yr}}$$

2. During Construction Infiltration Calculation

2a. Wet Conditions precip = $\frac{45.62\ in}{yr}$ Infiltration $\frac{45.62\ in}{yr} \times 25\% = \frac{11.40\ in}{yr}$

$$7.5\ yrs \times 40\ AC \times \frac{11.40\ in}{yr} \times \frac{43560\ ft^2}{AC} \times \frac{1ft}{12in} \times \frac{7.48\ gal}{ft^3}$$

$= \underline{92,860,800\ gal}$

2b. Dry Conditions precip = $\frac{18.06\ in}{yr}$ Infiltration $\frac{18.06\ in}{yr} \times 25\% = \frac{4.52\ in}{yr}$

$$7.5\ yrs \times 40\ AC \times \frac{4.52\ in}{yr} \times \frac{43560\ ft^2}{AC} \times \frac{1ft}{12in} \times \frac{7.48\ gal}{ft^3}$$

$= \underline{36,818,700\ gal}$

2c. Average Conditions precip = $\frac{34.03\ in}{yr}$ Infiltration $\frac{34.03\ in}{yr} \times 25\% = \frac{8.51\ in}{yr}$

$$7.5\ yrs \times 40\ AC \times \frac{8.51\ in}{yr} \times \frac{43560\ ft^2}{AC} \times \frac{1ft}{12in} \times \frac{7.48\ gal}{ft^3}$$

$= \underline{69,320,100\ gal}$

V. <u>Mine Pit - Assumptions</u>:

A. The 1977 monthly temperature and precipitation N.O.A.A. data for Weyerhaeuser, WI were used to represent wet precipitation conditions.

B. The 1976 monthly temperature and precipitation N.O.A.A. data for Weyerhaeuser, WI were used to represent dry precipitation conditions.

C. The average of the 1960 through 1988 monthly temperature and precipitation N.O.A.A. data for Weyerhaeuser, WI was used to represent average precipitation conditions.

D. The mine pit consists of 32 acres.

E. After mining is complete, stored material will be put back into the pit. The pit will be restored to a few feet higher than preconstruction grades. Therefore, the construction and post construction water budget conditions are the same. The existing ground slopes are approximately 2%, 4%, and 8%.

F. The mine pit has a life of 7.9 years from preproduction through reclamation.

G. The pit will be mined in two phases. Phase I will be open the entire operating life of the pit. Phase II will be open beginning the fourth quarter of the first year and be open the remainder of the operating life of the pit.

H. Evaporation from bare soils is approximately 50% of the total precipitation (U.S. EPA, 1975).

I. There will be no infiltration in the pit during construction because the pit is being dewatered.

J. During backfilling 50% of runoff will be non-contact runoff and 50% will be contact runoff.

VI. Mine Pit Infiltration, Precipitation, and Runoff Calculations

1.) Preconstruction and Post Construction
2%, 4%, and 8% slopes.

1a. Wet Conditions - Infiltration

2% Slope

$$6 \text{ AC} \times \frac{16.27 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

$$= \frac{2{,}650{,}600 \text{ gal}}{\text{yr}}$$

4% Slope

$$14 \text{ AC} \times \frac{14.34 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

$$= \frac{5{,}451{,}100 \text{ gal}}{\text{yr}}$$

8% Slope

$$12 \text{ AC} \times \frac{13.04 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

$$= \frac{4{,}248{,}800 \text{ gal}}{\text{yr}}$$

$$\text{Total} = \frac{12{,}350{,}500 \text{ gal}}{\text{yr}}$$

1b. Dry Conditions - Infiltration

2% Slope

$$6 \text{ AC} \times \frac{7.9 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

$$= \frac{1{,}287{,}000 \text{ gal}}{\text{yr}}$$

4% Slope

$$14 \text{ AC} \times \frac{7.76 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^3}$$

$$= \frac{2{,}949{,}800 \text{ gal}}{\text{yr}}$$

8% Slope

$$12\ AC \times \frac{7.58\ in}{yr} \times \frac{43560\ ft^2}{AC} \times \frac{1ft}{12in} \times \frac{7.48\ gal}{ft^3}$$

$$= \frac{2,469,800\ gal}{yr}$$

$$\text{Total} = \frac{6,706,600\ gal}{yr}$$

1c. Average Conditions - Infiltration

2% Slope

$$6\ AC \times \frac{10.98\ in}{yr} \times \frac{43560\ ft^2}{AC} \times \frac{1ft}{12in} \times \frac{7.48\ gal}{ft^3}$$

$$= \frac{1,788,800\ gal}{yr}$$

4% Slope

$$14\ AC \times \frac{10.98\ in}{yr} \times \frac{43560\ ft^2}{AC} \times \frac{1ft}{12in} \times \frac{7.48\ gal}{ft^3}$$

$$= \frac{4,173,900\ gal}{yr}$$

8% Slope

$$12\ AC \times \frac{10.95\ in}{yr} \times \frac{43560\ ft^2}{AC} \times \frac{1ft}{12in} \quad \frac{7.48\ gal}{ft^3}$$

$$= \frac{3,567,800\ gal}{yr}$$

$$\text{Total} = \frac{9,530,500\ gal}{yr}$$

2. During Construction Precipitation and Runoff

2a. Wet Conditions

precip - $\frac{45.62\ in}{yr}$ Evaporation $\frac{45.62\ in}{yr} \times 50\% = \frac{22.81\ in}{yr}$

Precipitation and Runoff $\frac{45.62\ in}{yr} - \frac{22.81\ in}{yr} = \frac{22.81\ i}{yr}$

Mine Pit - Preproduction

$$16\ AC \times .33\ yr \times \frac{22.81\ in}{yr} \times \frac{43560\ ft^2}{AC} \times \frac{1\ ft}{12\ in} \times \frac{7.48\ gal}{ft^3}$$

$= \underline{3,270,100\ gal}$

Mine Pit - Phase I Open

$$16\ AC \times .42\ yr \times \frac{22.81\ in}{yr} \times \frac{43560\ ft^2}{AC} \times \frac{1ft}{12in} \times \frac{7.48\ gal}{ft^3}$$

$= \underline{4,162,000\ gal}$

Total Pit Area Open

$$32\ AC \times 5.58\ yr \times \frac{22.81\ in}{yr} \times \frac{43560\ ft^2}{AC} \times \frac{1ft}{12in} \times \frac{7.48\ gal}{ft^3}$$

$= \underline{110,590,000\ gal}$

Mine Pit - Restoration

$$32\ AC \times 1.58\ yr \times \frac{22.81\ in}{yr} \times \frac{43560\ ft^2}{AC} \times \frac{1ft}{12in} \times \frac{7.48\ gal}{ft^3}$$

$= \underline{31,314,100\ gal}$

2b. Dry Conditions

precip - $\frac{18.06\ in}{yr}$ Evaporation $\frac{18.06\ in}{yr} \times 50\% = \frac{9.03\ in}{yr}$

Precipitation and Runoff $\frac{18.06\ in}{yr} - \frac{9.03\ in}{yr} = \frac{9.03\ in}{yr}$

Mine Pit - Preproduction

$$16\ AC \times .33\ yr \times \frac{9.03\ in}{yr} \times \frac{43560\ ft^2}{AC} \times \frac{1\ ft}{12\ in} \times \frac{7.48\ gal}{ft^3}$$

$= \underline{1,294,600\ gal}$

Mine Pit - Phase I Open

$$16\ AC \times .42\ yr \times \frac{9.03\ in}{yr} \times \frac{43560\ ft^2}{AC} \times \frac{1ft}{12in} \times \frac{7.48\ gal}{ft^3}$$

$= \underline{1,647,600\ gal}$

Total Pit Area Open

$$32\ AC \times 5.58\ yr \times \frac{9.03\ in}{yr} \times \frac{43560\ ft^2}{AC} \times \frac{1ft}{12in} \times \frac{7.48\ gal}{ft^2}$$

$= \underline{43,780,400\ gal}$

Mine Pit - Restoration

$$32\ AC \times 1.58\ yr \times \frac{9.03\ in}{yr} \times \frac{43560\ ft^2}{AC} \times \frac{1\ ft}{12\ in} \times \frac{7.48\ gal}{ft^3}$$

$= \underline{12,396,600\ gal}$

2c. Average Conditions
precip - $\frac{34.03\ in}{yr}$ Evaporation $34.03 \times 50\% = \frac{17.02\ in}{yr}$

Precipitation and Runoff $\frac{34.03\ in}{yr} - \frac{17.02\ in}{yr} = \frac{17.01\ in}{yr}$

Mine Pit - Preproduction

$$16\ AC \times .33\ AC \times \frac{17.01\ in}{yr} \times \frac{43560\ ft^2}{AC} \times \frac{1\ ft}{12\ in} \times \frac{7.48\ gal}{ft^2}$$

$= \underline{2,438,600\ gal}$

Mine Pit - Phase I Open

$$16\ AC \times .42\ yr \times \frac{17.01\ in}{yr} \times \frac{43560\ ft^2}{AC} \times \frac{1ft}{12in} \times \frac{7.48\ gal}{ft^2}$$

$= \underline{3,103,700\ gal}$

Total Pit Area Open

$$32 \text{ AC} \times 5.58 \text{ yr} \times \frac{17.01 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1\text{ft}}{12\text{in}} \times \frac{7.48 \text{ gal}}{\text{ft}^2}$$

$= \underline{82,470,100 \text{ gal}}$

Mine Pit - Restoration

$$32 \text{ AC} \times 1.58 \text{ yrs} \times \frac{17.01 \text{ in}}{\text{yr}} \times \frac{43560 \text{ ft}^2}{\text{AC}} \times \frac{1 \text{ ft}}{12 \text{ in}} \times \frac{7.48 \text{ gal}}{\text{ft}^2}$$

$= \underline{23,351,800 \text{ gal}}$

2d. Open Pit Dewatering

- Maximum "Best Engineering Judgement" inflow is estimated to be 260 gpm during production.
- Minimum "Best Engineering Judgement" inflow is estimated to be 110 gpm at the end of mining.
- Assume simple arithmetic average for inflow over pit life after Phase I. This is conservative since decrease in inflow is not a straight line function.

$$\text{Average inflow} = \frac{110+260}{2} = 185 \text{ gpm}$$

$$185 \text{ gpm} \times \frac{60 \text{ min}}{\text{hr}} \times \frac{24 \text{ hr}}{\text{day}} \times \frac{365 \text{ days}}{\text{yr}}$$

$$= \frac{97{,}236{,}000 \text{ gal}}{\text{yr}}$$

$$97{,}236{,}000 \text{ gal/yr} \times \frac{\text{ft}^3}{7.48 \text{ gal}} \times \frac{1}{32 \text{ AC}} \times \frac{\text{AC}}{43560 \text{ ft}^2} \times \frac{12 \text{ in}}{1 \text{ ft}}$$

$$= \frac{111.90 \text{ in}}{\text{yr}}$$

Calculations Prepared By: JSK Date: 3/15/89

Calculations Checked By: JWS Date: 3/29/89

Calculations Revised By: JWS Date: 12/10/89

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	Project: Permit Page: 1 of 8
	Prepared by: [illegible] Date: 3-15-89
	Checked by: [illegible] Date: 3/20/89

DURING CONSTRUCTION WATER BUDGET

TYPE I STOCKPILE

	RUNOFF	EVAP	INFIL	PRECIP
WET CONDITIONS				
gallons ($\times 10^6$)	185.722	92.861	92.861	371.444
inches/yr.	22.81	11.40	11.40	45.61
DRY CONDITIONS				
gallons ($\times 10^6$)	73.638	36.819	36.819	147.276
inches/yr.	9.04	4.51	4.51	18.06
AVERAGE CONDITIONS				
gallons ($\times 10^6$)	138.640	69.320	69.320	277.280
inches/yr.	17.02	8.51	8.51	34.04

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	Checked by: JJWS	Date: 3/29/89

DURING CONSTRUCTION WATER BUDGET

TYPE II STOCKPILE

	NONCONT. RUNOFF[1]	CONT. RUNOFF[2]	EVAP	INFIL	LEACH[3]	PRECIP
WET CONDITIONS						
AREA OPEN BEFORE FILLING						
gallons ($\times 10^6$)	8.358	0	4.179	4.179	0	16.716
inches/yr.	22.81	0	11.40	11.40	0	45.61
PHASE I FILLING						
gallons ($\times 10^6$)	0	26.440	13.220	0	13.220	52.88
inches/yr.	0	22.81	11.40	0	11.40	45.61
PHASE II OPEN NO FILLING						
gallons ($\times 10^6$)	19.528	0	9.764	9.764	0	39.052
inches/yr	22.81	0	11.40	11.40	0	45.61
PHASE I + II FILLING						
gallons ($\times 10^6$)	0	59.338	29.669	0	29.669	118.676
inches/yr.	0	22.81	11.40	0	11.40	45.61
Average over life of site (in/yr)	7.76	15.05	11.40	3.88	7.52	45.61

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TYPE II STOCKPILE CONT'D

	NONCONT RUNOFF[1]	CONT. RUNOFF[2]	EVAP	INFIL	LEACH[3]	PRECIP
DRY CONDITIONS						
AREA OPEN BEFORE FILLING						
gallons ($\times 10^6$)	3.306	0	1.653	1.653	0	6.612
inches/yr.	9.02	0	4.51	4.51	0	18.04
PHASE I FILLING						
gallons ($\times 10^6$)	0	10.46	5.23	0	5.23	20.92
inches/yr	0	9.02	4.51	0	4.51	18.04
PHASE II OPEN NO FILLING						
gallons ($\times 10^6$)	7.726	0	3.863	3.863	0	15.452
inches/yr	9.02	0	4.51	4.51	0	18.04
PHASE I + II FILLING						
gallons ($\times 10^6$)	0	23.476	11.738	0	11.738	46.952
inches/yr.	0	9.02	4.51	0	4.51	18.04
Average over life of site (in/yr)	3.07	5.95	4.51	1.54	2.97	18.04

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	Checked by: JJS	Date: 3/29/89

TYPE II STOCKPILE CONT'D

	NONCONT RUNOFF [1]	CONT. RUNOFF [2]	EVAP	INFIL	LEACH [3]	PRECIP
AVERAGE CONDITIONS						
AREA OPEN BEFORE FILLING						
gallons ($\times 10^6$)	6.238	0	3.119	3.119	0	12.476
inches/yr	17.02	0	8.51	8.51	0	34.04
PHASE I FILLING						
gallons ($\times 10^6$)	0	19.36	9.868	0	9.868	38.72
inches/yr	0	17.02	8.51	0	8.51	34.04
PHASE II OPEN NO FILLING						
gallons ($\times 10^6$)	14.576	0	7.288	7.288	0	29.152
inches/yr.	17.02	0	8.51	8.51	0	34.04
PHASE I + II FILLING						
gallons ($\times 10^6$)	0	44.30	22.148	0	22.148	88.596
inches/yr.	0	17.02	8.51	0	8.51	34.04
Average over site life (in/yr)	5.79	11.23	8.51	2.90	5.61	34.04

1 Noncontact runoff directed to natural drainage features.

2 Contact runoff directed to the wastewater treatment plant.

3 Leachate directed to the wastewater treatment plant.

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DURING CONSTRUCTION WATER BUDGET

MINE PIT

	NONCONTACT PRECIP/RUNOFF[1]	CONTACT PRECIP/RUNOFF[2]	EVAP	INFIL	PRECIP	OPER. LIFE[3] DEWATERING
WET CONDITIONS PREPROD.						
.33 gallons (x10⁶)	4.905	0	1.635	0	6.54	97.2
inches/yr	34.21	0	11.40	0	45.62	111.90
.42 PHASE I MINING						
gallons (x10⁶)	0	6.243	2.081	0	8.324	97.2
inches/yr	0	34.21	11.40	0	45.62	111.90
TOTAL PIT						
5.58 gallons (x10⁶)	0	165.88	55.29	0	221.18	97.2
inches/yr	0	34.21	11.40	0	45.62	111.90
1.58 Restoration						
gallons (x10⁶)	15.65	15.65	15.65	15.65	62.628	0
inches/yr	11.40	11.40	11.40	11.40	45.62	0
Average over life of site (in/yr)	3.70	28.26	11.40	2.28	45.62	89.7

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	Checked by: JWS	Date: 3/29/89
	Revised By: JWS	12/10/89

MINE PIT CON'T

	NONCONTACT PRECIP/RUNOFF[1]	CONTACT PRECIP/RUNOFF[2]	EVAP	INFIL	PRECIP	OPER. LIFE DEWATERING
DRY CONDITIONS PREPROD						
gallons ($\times 10^6$)	1.941	0	.647	0	2.588	97.2
inches/yr	13.54	0	4.51	0	18.06	111.90
PHASE I MINING						
gallons ($\times 10^6$)	0	2.472	.824	0	3.296	97.2
inches/yr	0	13.54	4.51	0	18.06	111.90
TOTAL PIT						
gallons ($\times 10^6$)	0	65.67	21.89	0	87.560	97.2
inches/yr	0	13.54	4.51	0	18.06	111.90
Restoration						
gallons ($\times 10^6$)	6.10	6.20	6.20	6.20	24.794	0
inches/yr	4.52	[illegible]	4.52	4.52	18.06	0
Average over life of site (in/yr)	1.46	11.18	4.51	.90	18.06	89.7

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	Checked by: JWS	Date: 3/29/89
	Revised by: JWS	12/10/89

MINE PIT CON'T

	NONCONTACT PRECIP/RUNOFF[1]	CONTACT PRECIP/RUNOFF[2]	EVAP.	INFIL	PRECIP	OPER. LIFE DEWATERING[3]
AVERAGE CONDITIONS PREPROD.						
gallons ($\times 10^6$)	3.658	0	1.219	0	4.878	97.2
inches/yr	25.51	0	8.50	0	34.02	111.90
PHASE I MINING						
gallons ($\times 10^6$)	0	4.656	1.552	0	6.208	97.2
inches/yr	0	25.51	8.50	0	34.02	111.90
TOTAL PIT						
gallons ($\times 10^6$)	0	123.705	41.235	0	164.94	97.2
inches/yr	0	25.51	8.50	0	34.02	111.90
Restoration						
gallons ($\times 10^6$)	11.68	11.68	11.68	11.68	46.704	0
inches/yr	8.50	8.50	8.50	8.50	34.02	0
Average over life of site (IN/yr)	2.76	21.07	8.50	1.70	34.02	89.7

Foth & Van Dyke	Client: Kennecott	Scope I.D.: 87K10
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	Checked by: JEWS	Date: 3/21/89

1 Noncontact precipitation/runoff pumped to settling ponds.

2 Contact precipitation/runoff pumped to wastewater treatment plant.

3 This water is discharged to surface water either through the wastewater treatment plant or settling ponds.

CLIENT Kennecott

PROJECT

PROJECT NO. 87 K10

WATER BALANCE

2% slope

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	YEAR
T	0.6	19.2	36.7	51.3	64.0	62.0	71.2	62.1	57.3	45.2	31.2	14.8	43.0
I	0	0	0.37	3.18	6.82	6.19	9.27	6.22	4.77	1.78	0	0	38.60
UPET	0	0	0.01	0.07	0.11	0.11	0.14	0.11	0.09	0.04	0	0	
r	24	24.3	30.6	33.9	38.4	38.7	39.3	36.3	31.2	28.2	23.7	22.5	
PET	0	0	0.31	2.37	4.22	4.23	5.50	3.99	2.81	1.13	0	0	
P	0.91	1.06	5.75	3.83	3.62	5.22	5.6	6.78	5.85	3.18	1.46	2.36	45.62
Cr/o	–	0.5	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	–	–	
RO	–	2.90	0.75	0.50	0.47	0.68	0.73	0.88	0.76	0.41	–	–	8.08
I	-	2.89	5.0	3.33	3.15	4.54	4.87	5.90	5.09	2.77	–	-	
I-PET	-	2.89	4.69	0.96	-1.07	0.31	-0.63	1.91	2.28	1.64	–	-	
ACC-WL				0	-1.07	-1.07	-1.7						
ST	12.0	12.0	12.0	12.0	10.97	10.97	10.41	12.0	12.0	12.0	12.0	12.0	
ΔST	0	0	0	0	1.03	0	0.56	-1.59	0	0	0	0	0
AET	0	0	0.31	2.37	2.12	4.23	4.31	3.99	2.81	1.13	0	0	21.27
PERC	0	2.89	4.69	0.96	0	0.31	0	3.50	2.28	1.64	0	0	16.27

= PERC + AET + ΔST + R/O

= 16.27 + 21.27 + 0 + 8.08

= 45.62

NOTES:

LAT = 45°26'

LONG = 91°25'

AVAILABLE WATER IN FINAL COVER = 12"

PRECIP. & TEMP. FROM: Wet Year - 1977

OTHER: N.O.A.A Data - Weyerhauser, WI

BY USK DATE 3-15-89	CHECKED BY DMR DATE 3-31-89	N25 Foth & Van Dyke engineers architects

CLIENT Kennecott

PROJECT

PROJECT NO. 87 K1D

WATER BALANCE

4% slope

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	YEAR
T	0.6	19.2	36.7	51.3	64.0	62.0	71.2	62.1	57.3	45.2	31.2	14.8	43.0
I	0	0	0.37	3.18	6.82	6.19	9.27	6.22	4.77	1.78	0	0	38.60
UPET	0	0	0.01	0.07	0.11	0.11	0.14	0.11	0.09	0.04	0	0	
r	24	24.3	30.6	33.9	38.4	38.7	39.3	36.3	31.2	28.2	23.7	22.5	
PET	0	0	0.31	2.37	4.22	4.23	5.50	3.99	2.81	1.13	0	0	
P	0.91	1.06	5.75	3.83	3.62	5.22	5.6	6.78	5.85	3.18	1.46	2.36	45.62
Cr/o	-	-	0.5	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	-	
RO	-	-	5.04	0.61	0.58	0.84	0.90	1.08	0.94	0.51	0.23	-	10.73
I	-	-	5.04	3.22	3.04	4.38	4.70	5.70	4.91	2.67	1.23	-	
I-PET	-	-	4.73	0.85	-1.18	0.15	-0.8	1.71	2.10	1.54	1.23	-	
ACC-WL					-1.18	-1.18	-2.03						
ST	12.0	12.0	12.0	12.0	10.87	11.02	10.12	11.83	12.0	12.0	12.0	12.0	
ΔST	0	0	0	0	1.13	-0.15	0.9	-1.71	-0.17	0	0	0	0
AET	0	0	0.31	2.37	1.91	4.23	3.80	3.99	2.81	1.13	0	0	20.55
PERC	0	0	4.73	0.85	0	0.3	0	3.42	2.27	1.54	1.23	0	14.34

= PERC + AET + ΔST + R/O

= 14.34 + 20.55 + 0 + 10.73

= 45.62

NOTES:

LAT = 45°26'

LONG = 91°25'

AVAILABLE WATER IN FINAL COVER = 12"

PRECIP. & TEMP. FROM: Wet Year - 1977

OTHER: N.O.A.A Data - Weyerhauser, WI

BY USK

DATE 3-15-89

CHECKED BY DMR

DATE 3-31-89

N26

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CLIENT Kennecott

PROJECT

PROJECT NO. 87 K10

WATER BALANCE

8% slope

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	YEAR
T	0.6	19.2	36.7	51.3	64.0	62.0	71.2	62.1	57.3	45.2	31.2	14.8	43.0
I	0	0	0.37	3.18	6.82	6.19	9.27	6.22	4.77	1.78	0	0	38.60
UPET	0	0	0.01	0.07	0.11	0.11	0.14	0.11	0.09	0.04	0	0	
r	24	24.3	30.6	33.9	38.4	38.7	39.3	36.3	31.2	28.2	23.7	22.5	
PET	0	0	0.31	2.37	4.22	4.23	5.50	3.99	2.81	1.13	0	0	
P	0.91	1.06	5.75	3.83	3.62	5.22	5.6	6.78	5.85	3.18	1.46	2.36	45.62
Cr/o	-	-	0.5	0.20	0.20	0.20	0.20	0.20	0.20	0.20	-	-	
RO	-	-	5.77	0.77	0.72	1.04	1.12	1.36	1.17	0.64	-	-	12.59
I	-	-	5.77	3.06	2.90	4.18	4.48	5.42	4.68	2.54	-	-	
I-PET	-	-	5.46	0.69	-1.32	-0.05	-1.02	1.43	1.87	1.41	-	-	
ACC-WL					-1.32	-1.37	-2.39						
ST	12.0	12.0	12.0	12.0	10.75	10.70	9.82	11.25	12.0	12.0	12.0	12.0	
ΔST	0	0	0	0	1.25	0.05	0.88	-1.43	-0.75	0	0	0	0
AET	0	0	0.31	2.37	1.65	4.13	3.60	3.99	2.81	1.13	0	0	19.99
PERC	0	0	5.46	0.69	0	0	0	2.86	2.62	1.41	0	0	13.04

= PERC + AET + ΔST + R/O

= 13.04 + 19.99 + 0 + 12.59

= 45.62

NOTES:

LAT : 45° 26'

LONG : 91° 25'

AVAILABLE WATER IN FINAL COVER = 12"

PRECIP. & TEMP. FROM: Wet Year - 1977

OTHER: N.O.A.A Data - Weyerhauser, WI

BY JSK
DATE 3-15-89

CHECKED BY DMR
DATE 3-31-89

N27

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PROJECT

PROJECT NO. 87K10

WATER BALANCE

2% slope

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	YEAR
T	8.96	15.0	28.23	43.61	55.29	63.23	67.93	65.39	56.71	45.64	30.79	14.78	41.35
I	0	0	0	1.47	4.22	6.57	8.13	7.28	4.60	1.88	0	0	34.15
UPET	0	0	0	0.04	0.09	0.11	0.13	0.12	0.09	0.05	0	0	
r	24	24.3	30.6	33.9	38.4	38.7	39.3	36.3	31.2	28.2	23.7	22.5	
PET	0	0	0	1.36	3.46	4.26	5.11	4.36	2.81	1.41	0	0	
P	1.14	0.88	1.92	2.62	3.44	4.17	4.33	4.07	4.61	2.76	2.76	1.33	34.03
Cr/o	-	-	0.5	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	-	
RO	-	-	2.64	0.34	0.45	0.54	0.56	0.53	0.60	0.36	0.36	-	6.38
I	-	-	2.63	2.28	2.99	3.63	3.77	3.54	4.01	2.40	2.40	-	
I-PET	-	-	2.63	0.92	-0.47	-0.63	-1.34	-0.82	1.20	0.99	2.40	-	
ACC-WL					-0.47	-1.1	-2.44	-3.26					
ST	12.0	12.0	12.0	12.0	11.54	10.95	9.78	9.15	10.35	11.34	12.0	12.0	
Δ ST	0	0	0	0	0.46	0.59	1.17	0.63	-1.20	-0.99	-0.66	0	0
AET	0	0	0	1.36	2.53	3.04	2.60	2.91	2.81	1.41	0	0	16.66
PERC	0	0	2.63	0.92	0	0	0	0	2.4	1.98	3.05	0	10.98

= PERC + AET + ΔST + R/O

= 10.98 + 16.66 + 0 + 6.38

= 34.02

NOTES:

LAT = 45°26'

LONG = 91°25'

AVAILABLE WATER IN FINAL COVER =

PRECIP. & TEMP. FROM: Average Monthly Precip & Temp. 1960-1988

OTHER: N.O.A.A. Data - Weyerhauser, Wi

BY JSK	CHECKED BY DMR	N28 Foth & Van Dyke engineers architects
DATE 3-14-89	DATE 3-31-89	

F.&V.D. 3-83

CLIENT Kennecott

PROJECT

PROJECT NO. 87K10

WATER BALANCE

4% slope

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	YEAR
T	8.96	15.0	28.23	43.61	55.29	63.23	67.93	65.39	56.71	45.64	30.79	14.78	41.35
I	0	0	0	1.47	4.22	6.57	8.13	7.28	4.60	1.88	0	0	34.15
UPET	0	0	0	0.04	0.09	0.11	0.13	0.12	0.09	0.05	0	0	
r	24	24.3	30.6	33.9	38.4	38.7	39.3	36.3	31.2	28.2	23.7	22.5	
PET	0	0	0	1.36	3.46	4.26	5.11	4.36	2.81	1.41	0	0	
P	1.14	0.88	1.92	2.62	3.44	4.17	4.33	4.07	4.61	2.76	2.76	1.33	34.03
C r/o	–	–	0.5	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	-	
RO	–	-	2.64	0.42	0.55	0.67	0.69	0.65	0.74	0.44	0.44	-	7.24
I	–	-	2.63	2.20	2.89	3.50	3.64	3.42	3.87	2.32	2.32	-	
I-PET	–	-	2.63	0.84	-0.57	-0.76	-1.47	-0.94	1.06	0.91	2.32	-	
ACC-WL					-0.57	-1.33	-2.80	-3.74					
ST	12.0	12.0	12.0	12.0	11.44	10.74	9.50	8.78	9.84	10.75	12.0	12.0	
ΔST	0	0	0	0	0.56	0.70	1.24	0.72	-1.06	-0.91	-1.25	0	0
AET	0	0	0	1.36	2.33	2.80	2.40	2.70	2.81	1.41	0	0	15.81
PERC	0	0	2.63	0.84	0	0	0	0	2.12	1.82	3.57	0	10.98

= PERC + AET + ΔST + R/O

= 10.98 + 15.81 + 0 + 7.24

= 34.03

NOTES:

LAT = 45°26'

LONG = 91° 25'

AVAILABLE WATER IN FINAL COVER = 12"

PRECIP. & TEMP. FROM: Average Monthly Precip & Temp. 1960-1988

OTHER: N.O.A.A. Data - Weyerhauser, WI

BY JSK — CHECKED BY DMR

DATE 3-15-89 — DATE 3-31-89

N29 Foth & Van Dyke engineers architects

F&VD 3 83

CLIENT Kennecott

PROJECT

PROJECT NO. 87K10

WATER BALANCE

8% slope

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	YEAR
T	8.96	15.0	28.23	43.61	55.29	63.23	67.93	65.39	56.71	45.64	30.79	14.78	41.35
I	0	0	0	1.47	4.22	6.57	8.13	7.28	4.60	1.88	0	0	34.15
UPET	0	0	0	0.04	0.09	0.11	0.13	0.12	0.09	0.05	0	0	
r	24	24.3	30.6	33.9	38.4	38.7	39.3	36.3	31.2	28.2	23.7	22.5	
PET	0	0	0	1.36	3.46	4.26	5.11	4.36	2.81	1.41	0	0	
P	1.14	0.88	1.92	2.62	3.44	4.17	4.33	4.07	4.61	2.76	2.76	1.33	34.03
C r/o	-	-	0.5	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	-	
RO	-	-	2.64	0.52	0.69	0.83	0.87	0.81	0.92	0.55	0.55	-	8.38
I	-	-	2.63	2.10	2.75	3.34	3.46	3.26	3.69	2.21	2.21	-	
I-PET	-	-	2.63	0.74	-0.71	-0.92	-1.65	-1.1	0.88	0.80	2.21	-	
ACC-WL					-0.71	-1.63	-3.28	-4.38					
ST	12.0	12.0	12.0	12.0	11.31	10.47	9.13	8.32	9.20	10.00	12.0	12.0	
ΔST	0	0	0	0	0.69	0.84	1.34	0.81	-0.88	-0.80	2.00	0	0
AET	0	0	0	136	2.06	2.50	2.12	2.44	2.81	1.41	0	0	14.70
PERC	0	0	2.63	0.74	0	0	0	0	1.76	1.60	4.22	0	10.95

= PERC + AET + ΔST + R/O

= 10.95 + 14.70 + 0 + 8.38

= 34.03

NOTES:

LAT = 45°26'

LONG = 91°25'

AVAILABLE WATER IN FINAL COVER = 12"

PRECIP. & TEMP. FROM: Average Monthly Precip & Temp. 1960-1988

OTHER: N.O.A.A. Data - Weyerhauser, Wi

BY JSK

DATE 3-15-89

CHECKED BY DMR

DATE 3-31-89

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CLIENT Kennecott

PROJECT

PROJECT NO. 87K10

WATER BALANCE

2% slope

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	YEAR
T	6.0	21.0	25.1	44.7	53.6	67.3	70.6	68.2	57.1	42.7	25.2	6.7	40.7
I	0	0	0	1.68	3.76	7.92	9.06	8.23	4.72	1.30	0	0	36.67
UPET	0	0	0	0.04	0.07	0.13	0.14	0.13	0.09	0.04	0	0	
r	24	24.3	30.6	33.9	38.4	38.7	39.3	36.3	31.2	28.2	23.7	22.5	
PET	0	0	0	1.36	2.69	5.03	5.50	4.72	2.81	1.13	0	0	
P	2.05	0.92	3.22	2.35	1.41	2.13	2.42	1.40	1.24	0.57	0	0.35	18.06
Cr/o	–	-	0.5	0.13	0.13	0.13	0.13	0.13	0.13	0.13	–	–	
RO	-	-	3.27	0.31	0.18	0.28	0.31	0.18	0.16	0.07	–	-	4.76
I	–	-	3.27	2.04	1.23	1.85	2.11	1.22	1.08	0.50	–	–	
I-PET	–	–	3.27	0.68	-1.46	-3.18	-3.39	-3.50	-1.73	-0.63	–	–	
ACC-WL					-1.46	-4.64	-8.03	-11.53	-13.26	-13.89			
ST	3.76	3.76	7.03	7.71	10.62	8.15	6.14	4.58	3.97	3.76	3.76	3.76	
ΔST	0	0	-3.27	-0.68	-2.91	2.47	2.01	1.56	0.61	0.21	0	0	0
AET	0	0	0	1.36	4.14	-0.62	0.10	-0.34	0.47	0.29	0	0	5.40
PERC	0	0	6.54	1.36	0	0	0	0	0	0	0	0	7.90

= PERC + AET + ΔST + R/O

= 7.90 + 5.40 + 0 + 4.76

= 18.06

NOTES:

LAT : 45°26'

LONG : 91° 25'

AVAILABLE WATER IN FINAL COVER =

PRECIP. & TEMP. FROM: Dry Year - 1976

OTHER: N.O.A.A. Data - Weyerhauser, WI

BY JSK

DATE 3-15-89

CHECKED BY DMR

DATE 3-31-89

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CLIENT Kennecott

PROJECT

PROJECT NO. 87K10

WATER BALANCE

4% Slope

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	YEAR
T	6.0	21.0	25.1	44.7	53.6	67.3	70.6	68.2	57.1	42.7	25.2	6.7	40.7
I	0	0	0	1.68	3.76	7.92	9.06	8.23	4.72	1.30	0	0	36.67
UPET	0	0	0	0.04	0.07	0.13	0.14	0.13	0.09	0.04	0	0	
r	24	24.3	30.6	33.9	38.4	38.7	39.3	36.3	31.2	28.2	23.7	22.5	
PET	0	0	0	1.36	2.69	5.03	5.50	4.72	2.81	1.13	0	0	
P	2.05	0.92	3.22	2.35	1.41	2.13	2.42	1.40	1.24	0.57	0	0.35	18.06
C r/o	-	-	0.50	0.16	0.16	0.16	0.16	0.16	0.16	0.16	-	-	
RO	-	-	3.27	0.38	0.23	0.34	0.39	0.22	0.20	0.09	-	-	5.12
I	-	-	3.27	1.97	1.18	1.79	2.03	1.18	1.04	0.48	-	-	
I-PET	-	-	3.27	0.61	-1.51	-3.24	-3.47	-3.54	-1.77	-0.65	-	-	
ACC-WL					-1.51	-4.75	-8.22	-11.76	-13.53	-14.18			
ST	3.68	3.68	6.95	7.56	10.58	8.07	6.04	4.50	3.88	3.68	3.68	3.68	
ΔST	0	0	+3.27	-0.61	-3.02	2.51	2.03	1.54	0.62	0.20	0	0	0
AET	0	0	0	1.36	4.20	-0.72	0	-0.36	0.42	0.28	0	0	5.18
PERC	0	0	6.54	1.22	0	0	0	0	0	0	0	0	7.76

= PERC + AET + ΔST + R/O

= 7.76 + 5.18 + 0 + 5.12

= 18.06

NOTES:

LAT : 45°26'

LONG : 91° 25'

AVAILABLE WATER IN FINAL COVER = 12"

PRECIP. & TEMP. FROM: Dry Year - 1976

OTHER: N.O.A.A. Data - Weyerhauser, WI

BY JSK

DATE 3-15-89

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DATE 3-31-89

N32

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PROJECT

PROJECT NO. 87K10

WATER BALANCE

8% slope

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	YEAR
T	6.0	21.0	25.1	44.7	53.6	67.3	70.6	68.2	57.1	42.7	25.2	6.7	40.7
I	0	0	0	1.68	3.76	7.92	9.06	8.23	4.72	1.30	0	0	36.67
UPET	0	0	0	0.04	0.07	0.13	0.14	0.13	0.09	0.04	0	0	
r	24	24.3	30.6	33.9	38.4	38.7	39.3	36.3	31.2	28.2	23.7	22.5	
PET	0	0	0	1.36	2.69	5.03	5.50	4.72	2.81	1.13	0	0	
P	2.05	0.92	3.22	2.35	1.41	2.13	2.42	1.40	1.24	0.57	0	0.35	18.06
Cr/o	–	–	0.5	0.20	0.20	0.20	0.20	0.20	0.20	0.20	–	–	
RO	–	–	3.27	0.47	0.28	0.43	0.48	0.28	0.25	0.11	–	–	5.57
I	–	–	3.27	1.88	1.13	1.70	1.94	1.12	0.99	0.46	–	–	
I-PET	–	–	3.27	0.52	-1.56	-3.33	-3.56	-3.60	-1.82	-0.67	–	–	
ACC-WL					-1.56	-4.89	-8.45	-12.05	-13.87	-14.54			
ST	3.57	3.57	6.84	7.36	10.53	7.98	5.93	4.39	3.77	3.57	3.57	3.57	
ΔST	0	0	-3.27	-0.52	-3.17	2.55	2.05	1.54	0.62	0.20	0	0	0
AET	0	0	0	1.36	4.30	-.85	-0.11	-0.42	0.37	0.26	0	0	4.91
PERC	0	0	6.54	1.04	0	0	0	0	0	0	0	0	7.58

= PERC + AET + ΔST + R/O

= 7.58 + 4.91 + 0 + 5.57

= 18.06

NOTES:

LAT : 45°26'

LONG : 91° 25'

AVAILABLE WATER IN FINAL COVER = 12"

PRECIP. & TEMP. FROM: Dry Year - 1976

OTHER: N.O.A.A. Data - Weyerhausen, WI

BY JSK

DATE 3-15-89

CHECKED BY DMR

DATE 3-31-89

N33

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APPENDIX O

Analytical Methods for Determining Metals Content in Biological Tissues

METHOD 540.2

MERCURY

(Cold Vapor Technique)

1. Application

1.1 This method is applicable to the determination of mercury in fish tissue, river sediments, sewage sludges, paper pulp waste, and nonaqueous RCRA samples.

2. Summary of Method

2.1 Sample portions are weighed wet into test tubes and digested with a sulfuric-nitric acid digestion mixture. Hydrogen peroxide is added to aid in digestion of high fat (>10%) samples. The samples are digested in an aluminum block digester at 265°C ±5°C with no detectable loss of mercury. Potassium permaganate is added to ensure complete oxidation. The mercury content is determined by flameless atomic absorption spectrophotometry. The flameless AA procedure is a physical method based on absorption of radiation at 253.7 nm by mercury vapor. The mercury is reduced to the elemental state and aerated from solution.

3. Sample Handling and Preservation

3.1 Fish samples are blended in the field as whole fish and frozen. Once thawed for analysis samples are further homogenized in a blender. Other types of samples (sludges, sediments and other nonaqueous samples) are kept at 4°C or frozen until the digestion and % moisture can be performed.

4. Interferences

4.1 The same type of interferences that may occur in water samples are also possible with fish or other environmental samples, i.e. sulfides, high copper, high chloride.

5. Apparatus

5.1 Samples are digested in Technicon pyrex partial reflux test tubes calibrated at 50 and 75 mL. The tubes are heated in a Technicon BD-40 Aluminum Block Digester Heating Unit.

5.2 Mercury measurements are made using a Perkin Elmer Model 370 atomic absorption spectrophotometer hooked up in conjunction with a Perkin-Elmer Model 56 Recorder.

Perkin-Elmer 370 Instrument Settings

Signal TC2
Slit Width 0.7 nm
Wavelength 253.7 nm
Compressed Air Flow .75 LPM

Perkin-Elmer 56 Recorder Settings
Chart speed 5 mm/min.
Rangle 1 mv

5.3 All glassware should be submerged in acatinox solution for 15 minutes, rinsed in 10% nitric acid followed by a rinse in distilled water. Next, all glassware is rinsed with 20% stannous chloride in 1 + 1 hydrochloric acid. Finally all glassware should be rinsed in triplicate with deionized water.

6. Reagents

6.1 Digestion mixture: Prepared by mixing concentrated sulfuric acid with concentrated nitric acid in a volumetric ratio of 4:1.

6.2 Hydroxylamine sulfate solution, 12% w/v: Prepared by dissolving 60 g reagent grade hydroxylamine sulfate and 60 g reagent grade sodium chloride in 500 mL deionized water.

6.3 Stannous chloride solution, 20% w/v: Prepared by dissolving 200 g reagent grade $SnCl_2$ in 1 litre 1:1 hydrochloric acid.

6.4 Mercuric chloride stock solution, 1000 µg/mL: Obtained from J. T. Baker.

6.5 Mercuric chloride working solution: Prepared by diluting the stock solution with 1% HCl in Milli-Q water to a concentration of 0.1 µg/mL Hg. A small amount of potassium dichromate (approx. 0.2 g/500 mL) is added as a preservative.

6.6 Potassium permaganate solution, 5% w/v: Prepared by dissolving 25 g $KMnO_4$ in 500 mL deionized water.

7. Experimental Procedure

7.1 Fish sample portions of 0.75 ± 0.05 g or 0.5 ± 0.05 g of wet sludge or sediment (nonaqueous samples) are added to 75 mL digestion tubes. Sample portions from 0.65 to 0.85 grams were tested with no observed matrix effects using 12.5 mL of digestion mixture. Blanks, standards, and spiked samples are prepared in exactly the same manner. Any adhering sample may be vortexed from the side of the vessel. The tubes are covered and allowed to stand overnight, ca. 24 hours.

7.2 2 mL of H_2O_2 is then added in a dropwise fashion to each tube. (Ten drops is added to each tube four times.) This proved effective on high fat samples. Caution should be used upon addition of H_2O_2 as reaction is quite vigorous.

7.3 The samples are next placed in a cold aluminum block digester and heated to 265°C for 30-75 minutes, or until continuous white fuming persists. Samples are removed and allowed to air cool for 10 minutes.

7.4 The sample tubes are then placed in a cool tap water bath, 18°C, and allowed to sit for 15-30 minutes. After cooling samples should be completely clear. (A brown or tan digestate indicates insufficient oxidant present. Mercury loss may have occurred. The sample must be rerun.)

7.5 Potassium permaganate is then added in a sufficient quantity to maintain a purple color. Ca. 2 mL. The potassium permaganate is added to ensure complete oxidation and removal of aromatic and nitrogen compounds that could interfere with photometric measurements.

7.6 The digested samples are allowed to cool for approximately 30 minutes. 10-20 mL of deionized water is added to prevent frothing and 2.5 mL 12% hydroxylamine solution is added to reduce the excess potassium permaganate. Next the volume is adjusted to 50 mL with deionized water.

7.7 20 mL of the sample is pipetted for analysis and 2.5 mL of 20% $SnCl_2$ solution is added and the released mercury vapor is swept through the mercury cold vapor system by a stream of compressed air.

7.8 The % moisure is determined for sludges, sediments and used to calculate the Hg concentration on a dry weight basis.

8. Precision and Accuracy

8.1 The accuracy and precision of the method was evaluated using National Bureau of Standards reference materials with certified concentrations of mercury. In addition, the precision was further evaluated by running one fish sample 21 times on different days. The results are shown in the following table.

		This Method				
Sample Material	Certified Value ug/g	µg/g (Mean value)	Range	# of Runs	CH_3HgCl Spike Recovery Average	Relative Std. Deviation
NBS Orchard Leaves	0.155 ± 0.015	0.148 ± 0.037	.127-.192	13	95.9%	12.4%
NBS Fly Ash	0.14 ± 0.01	0.12 ± 0.033	.10-.143	7	88.9%	14.3%
NBS Bovine Liver	0.016 ± 0.002	0.017 ± 0.005	.014-.023	15	90.5%	14.3%
Carp tissue	Not Applicable	0.131 ± 0.028	.116-.144	21	96.0%	6.6%

8.2 Using this method as described the detection limit is 0.01 µg/g Hg for all sample types analyzed.

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Method 620.1

Cadmium, Chromium, Copper, Lead and Zinc in Tissue

(Atomic Absorption)

1. Scope and Application

   1.1 This method is applicable to the determination of cadmium, chromium, copper, lead and zinc in fish and animal tissue.

2. Summary of Method

   2.1 Portions of well homogenized tissue are weighed directly in test tubes and digested with a mixture of sulfuric and nitric acids. Cadmium, chromium, copper, lead and zinc are determined directly on the digestate using an atomic absorption flame technique.

3. Sample Handling and Preservation

   3.1 Fish and other animal tissue is homogenized in the field using a large meat grinder. A portion is placed in a glass sample bottle and frozen. The samples remain frozen until analyzed.

4. Apparatus

   4.1 Technicon pyrex partial reflux test tubes calibrated at 50 mL.
   4.2 Technicon BD 40 Block Digestor.
   4.3 Balance, Autotaring toploader.
   4.4 Blender, Waring Commercial Blender equipped with a minicup.
   4.5 Routine laboratory glassware.
   4.6 Atomic absorption spectrophotometer, Perkin-Elmer model 403.

5. Reagents

   5.1 Nitric/sulfuric acid solution (3:1): Prepare a 3:1 nitric to sulfuric acid solution by adding 500 mL conc. sulfuric acid (Baker Instraanalyzed) to 1500 mL conc. nitric acid (Baker Instraanalyzed).
   5.2 Stock Standard Solutions: Certified atomic absorption standards commercially prepared by J. T. Baker Co.
   5.3 Mixed Standard Solutions.

6. Digestion Procedure

   6.1 Remove the samples from the freezer and allow to thaw briefly.
   6.2 Accurately weigh 5 ± 0.5 g (to the nearest 0.01 g) of tissue directly in the Technicon partial reflux test tube.
      6.2.1 Spike approximately 5% of the samples by adding 1 mL of mixed standard solution to the tissue in each of the tubes.
      6.2.2 Pipet aliquots of mixed standard solution, graduated over the concen-

tration range of interest, into four empty tubes. Process the standards in the same manner as the tissue and spiked samples.

6.3 Add 20 mL of sulfuric/nitric acid solution (5.1) to each tube.

6.4 If possible, allow the tubes to stand at room temperature (20-22°C) overnight to partially digest the tissue.

6.5 Place the tubes into the cool block digestor and SLOWLY increase the temperature to 60°C.

6.6 Allow the tubes to remain at 60°C for 1 hour or until most of the large pieces of tissue are broken down. (Note: If the samples are allowed to stand overnight before this process, the tissue breaks down quickly without any foaming. However, if this step is omitted, a VERY LONG slow temperature increase is needed to prevent excess foaming.)

6.7 Carefully vortex the tubes to wash down any small bits of tissue adhering to the sides of the tubes. (Caution: Vortex the tubes carefully; they are hot.)

6.8 Gradually increase the temperature from 60 to 120°C. Allow the tubes to remain at 120°C for 1 hour.

6.9 Remove the tubes from the block and allow to cool.

6.10 Bring the tubes to a volume of 50 mL with Milli-Q water, mix thoroughly and filter through glass wool into a 60 mL polyethylene bottle. (Note: The tubes are calibrated at 50 mL.)

6.11 Analyze the digestate for cadmium, chromium, copper, lead and zinc using the procedure outlined in Sections 7.1-7.6.

7. Analysis - Cadmium, chromium, copper, lead and zinc.

7.1 Analyze the digestate (6.11) using flame Atomic Absorption. Use an air-acetylene gas mixture.

7.2 Zero the instrument using a reagent blank consisting of 20 mL of 3:1 HNO_3-H_2SO_4 added to 30 mL of Milli-Q water.

7.3 Calibrate the instrument with the digested standards.

7.4 Note: Because the digestate has a viscous nature, nebulizer adjustment is particularly important.

7.5 The samples are very acidic; handle with extreme care. The analyst should wear plastic gloves when working with the samples.

7.6 To reduce corrosion, rinse the burner with copious amounts of Milli-Q water after use.

8. Precision and Accuracy

8.1 Precision and accuracy data are available in the Inorganic Chemistry Unit Quality Assurance Manual.

METHOD 630.1
ARSENIC AND SELENIUM IN ANIMAL TISSUE
(Atomic Absorption, Hydride)

1. Scope and Application

   1.1 This method is applicable to the determination of arsenic and selenium in fish tissue and other animal tissue.

2. Summary of Method

   2.1 Portions of well homogenized tissue are weighed directly into digestion beakers and ashed with an ashing aid in a muffle furnace. The ashes are dissolved in hydrochloric acid.

   2.2 The resulting solutions are analyzed for arsenic and/or selenium using hydride generation atomic absorption spectrophometry.

3. Sample Handling and Preservation

   3.1 Whole fish or filets are homogenized by field staff using a large meat grinder. A portion is placed in a glass sample bottle and frozen. No further grinding or blending is required.

   3.2 Animal tissues (other than fish) are cut into small chunks, placed in glass bottles and are frozen.

   3.3 At the lab animal tissue samples are thawed and blended using a waring blender and stainless steel minicup. If not immediately analyzed, the samples are refrozen.

4. Apparatus

   4.1 Top loading Balance, Ainsworth Model 200

   4.2 Waring Commercial Blender equipped with a minicup

   4.3 100 mL Pyrex (No. 100) beakers with watch glass covers

   4.4 Thelco model 26 Mechanical convection oven set at 105°C

   4.5 Muffle Furnace capable of stable heating at 500°C

   4.6 Atomic Absorption Spectrophotometer, Perkin-Elmer model 403, equipped with a strip chart recorder

   4.7 Hydride generation accessories (Figure 1)

5. Reagents

   5.1 Ethanol, 95%

5.2 Ashing Aid: Dissolve 200 g $Mg(NO_3)_2 \cdot 6H_2O$ in 500 mL MQ water. Add 20 g MgO (MCB) and a stirring bar.

5.3 Hydrochloric acid, conc.

5.4 1 M KI-9% Ascorbic Acid Solution. Dissolve 16.6g potassium iodide (KI) and 9g ascorbic acid in MQ water and dilute to 100 mL.

5.5 Sodium borohydride pellets: Available from Alfa-Ventron Chemicals.

5.6 Stock Standard Solutions: Baker "Instra-Analyzed" 1000 mg/L atomic absorption standard commercially prepared by J.T. Baker Chemical Co.

5.7 Organic As stock solution: Dissolve 0.19g cacodylic acid in about 75mL of MQ water, add 0.5 mL HNO_3, dilute to 100 mL and mix thoroughly.

5.8 Standard solutions: 1.0 mg/L As, 1.0 mg/L Se, 1.2 mg/L organic As. (To prepare the organic As solution, add 100 µL of stock solution to a 100 mL volumetric flask and dilute to the mark with MQ water.)

5.9 Hydrochloric acid 1:1.

5.10 Test tubes calibrated at 50 mL.

5.11 Milli-Q (MQ) reagent grade water, Millipore Corp. Bedford, MA.

6. Digestion Procedure

6.1 Remove the samples from the freezer and allow to thaw briefly.

6.2 Accurately weigh > 1g but < 1.5 g (to the nearest 0.01g) of tissue directly into the ashing beakers.

6.2.1 Spike approximately 5% of the samples by adding 2.0 mL of 1.2 ug/mL (organic) As solution and/or 2.0 ml Se(IV) standard solution. Duplicate approximately 10% of the samples.

6.2.2 Pipet 0, 1.0, 2.0, and 3.0 mL of inorganic 1.0 mg/L As and/or 1.0 mg/L Se standard solutions (5.7) into four empty beakers. Process these standards in the same manner as the tissue and spiked samples.

6.3 Add 3 mL ethanol and swirl.

6.4 Place the ashing aid bottle on a magnetic stir plate and begin stirring the solution. Pipet 10 mL of ashing aid solution into each beaker.

6.5 Using a glass stirring rod, mix the tissue and ashing aid to remove the tissue from the beaker surface. Cover beakers with watch glasses.

6.6 Place in 105°C oven and dry overnight.

6.7 Transfer the beakers to a cold muffle furnace and slowly raise the temperature of the furnace to 500°C. Leave at this temperature for a minimum of 24 hours.

6.8 After allowing to cool to near room temperature, rinse watch cover and beaker walls with a little MQ water and add 25 mL con HCl. Heat on a hot plate at 95°C for 30 minutes if Se is required or until the ashes dissolve if only As is required.

6.9 After cooling to room temperature, quantitatively transfer the solutions to the calibrated test tubes rinsing beakers several times with MQ water. Dilute to a final volume of 50 mL.

6.10 If both As and Se are to be analyzed, pipet 25 mL into 60 mL polyethylene bottles for As.

7. Analysis

7.1 Set up the PE 403 for hydride generation using an argon-hydrogen gas mixture at a 40/24 ratio. Use the three slot burner head at a height of 11 and depth of 2.9 markings on the 403.

7.1.1 For As determinations add 1.0 mL KI-Ascorbic acid solution (5.4) to each polyethylene bottle and allow to sit for one hour.

7.2 Pipet 10 mL of sample solution into the generator flask followed by 10 mL of 1:1 HCl and 20 ml of MQ water. (Final volume should always be 40 mL in the flask).

7.3 Attach the flask to the apparatus and purge with argon for 15 seconds and discontinue.

7.4 Add one $NaBH_4$ pellet to the flask by means of the dosing stopcock.

7.5 After collecting the hydrides in the balloon for 30 seconds, open the gas flow stopcock and allow the argon to sweep the hydride from the generator into the flame.

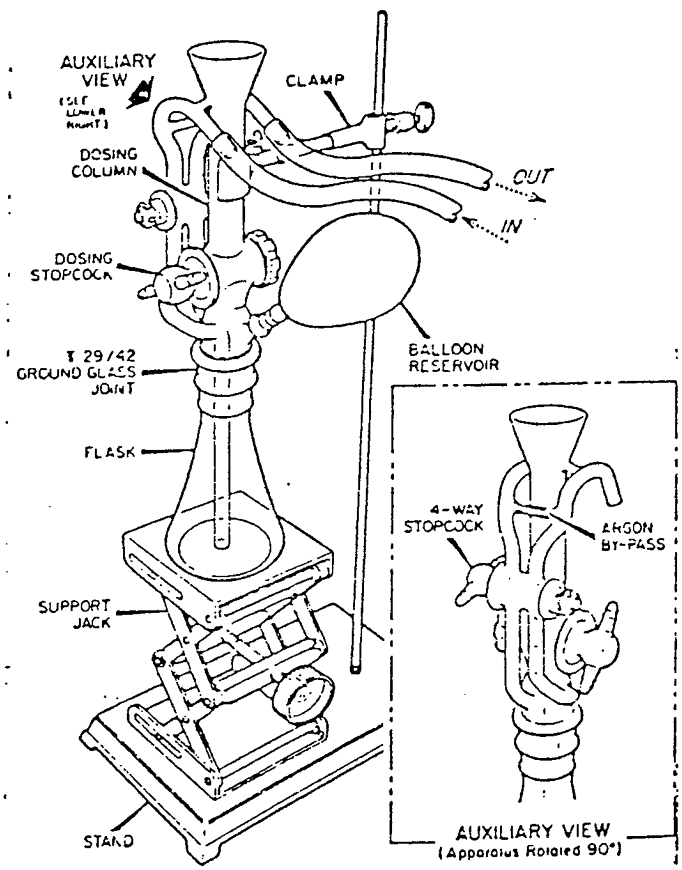
7.6 The absorbance is recorded on the strip chart recorder.

7.7 Determine the concentration of arsenic or selenium by comparing the sample peak heights with those of the digested standards plotted as the calibration curve.

8. Precision and Accuracy

8.1 Precision and accuracy data are available in the Inorganic Chemistry Unit Quality Assurance Manual.

Figure 1. Hydride Generation Apparatus



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APPENDIX P

Biotic Index Sorting Procedure
1983

BIOTIC INDEX SORTING PROCEDURE - 1983

1. Place contents of the jar into a large pan or tray containing a grid of 2-inch, consecutively numbered squares. The grid pattern may be on the bottom of the tray or on some suitable material placed under a transparent tray. If desired, alcohol can be removed by placing the sample in a US #30 mesh seive and washing with water before transferring to the pan.

2. Distribute the debris and arthropods as evenly as possible in the tray. Remove any large debris, being careful to not discard any arthropods with it. Samples with large numbers of organisms can be divided and sub-sampled.

3. Remove all arthropods from one grid at a time and place them in a jar containing 70 percent alcohol. Arthropods can be sorted to an identifiable taxonomic level and placed in separate jars. An arthropod is considered to lie within a grid if more than one-half of it is within the grid. The grids to be picked should be selected from a random number table and picked individually. Continue picking until at least 100 arthropods with B.I. values have been removed. The last grid should be totally picked, no matter how many arthropods end up in the sample.

3a. Alternative sorting procedure: A random number table works well on some samples, but not those with a lot of debris and few insects. Under these circumstances the following is suggested:

   a. randomly select a corner of the pan to start picking from,
   b. randomly select a direction to proceed (vertical or horizontal),
   c. pick grids in line.

   This semi-random method allows the debris to be pushed aside as sorting progresses.

4. Avoid sorting arthropods less than 3 mm in length, except for adult riffle beetles (Elmidae). Collect, but do not count, adult insects except for riffle beetles (Elmidae and Dryopidae). Adult beetles (Dytiscidae, Gryinidae, Hydrophilidae) and adult bugs (especially Corixidae) are frequently found in some samples but cannot be used in the HBI analysis.

2660A

MACROINVERTEBRATE/BIOTIC INDEX SAMPLING GUIDELINES - 1983

The following macroinvertebrate sampling guidelines are designed as standard operating procedures for routine investigations, basin assessments, pre and post studies, etc. The objective of these guidelines is to provide minimum requirements to assure data quality, and to assure that future data can be reliably compared to past data. These guidelines do not cover all possible sampling situations. However, investigators are expected to conform as closely as possible to these guidelines in all routine sampling programs which use the Hilsenhoff Biotic Index analysis system.

SAMPLING STRATEGY

Site Selection

The basic site selection criterion is that most sampling sites within a stream reach should have similar habitat characteristics. Of particular importance is substrate and current velocity.

Riffles, where flow is rapid and the substrate is composed of gravel or small stones, is the preferred sampling habitat. However, if riffles are not available at most sampling sites, the next best habitat which is available at most sites should be sampled. A variety of habitats found in most streams are suitable for macroinvertebrate sampling. The only exception is that nonflowing areas should not be sampled. In streams with poor habitat, artificial substrate samplers can be used.

General site selection criteria include:

1. Sample similar habitat at most sites (for example, do not sample a gravel riffle upstream and debris in a slower velocity area downstream);
2. Riffles with gravel or stone substrates are preferred;
3. Sample areas with a flow velocity of at least 0.5 ft/sec., preferably with gravel or stone substrates;
4. If areas with gravel or stone substrates are not available, sample debris in the fastest turbulent current;
5. Leaves, grass and other debris clinging to branches or snags are acceptable if nothing better can be found;
6. Avoid areas directly downstream from impoundments or bridges;
7. Avoid sampling silty substrates;
8. Streams without suitable habitat should be sampled with artificial substrates.

Replicate Sampling

For routine investigations three replicate samples should be taken at a control, or upstream site, and no replicates at other sites within a stream reach.

When conducting investigations for enforcement purposes or other potentially sensitive situations, three replicate samples at each site are suggested. It may not be necessary to process all samples, but replicates should at least be available if needed.

Sampling Seasons

Macroinvertebrate sampling in Wisconsin should generally be done from October to May. Because of ice conditions, autumn sampling should be done as late as possible before freeze up, and spring sampling should be done as soon after ice out and return to normal flow conditions as possible.

For routine investigations, sampling only one season is recommended. Spring sampling is preferred in most situations. However, there are situations where autumn sampling may be preferred.

To insure any future sampling can be correlated with past data it is important to collect water temperature and flow, or stage data when macroinvertebrate samples are taken. Future samples should be taken under similar physical conditions.

SAMPLING PROCEDURES

Sampling Methods

Sample with a D-frame net by holding the net firmly against the substrate and disturbing the substrate upstream from the net with your feet to dislodge arthropods. Do not try to push the net through the substrate. Let the arthropods wash downstream into the net. A few rocks, sticks or pieces of vegetation should be examined and sampled if necessary, to ensure that firmly attached insects are included in the sample.

Try to sample all suitable niches at each sampling site with equal effort. Do not sample areas at the site with flow velocity less than 0.5 ft/sec., or areas with substrate composed of sediment. In some situations, sampling along a transect is appropriate, in others an expanded effort at a site may be required.

When replicate samples are to be taken, sample from downstream to upstream to insure that an undisturbed area is sampled. A stream reach should also be sampled from downstream to upstream if sites are close together.

Number of Arthropods

A minimum of 100 arthropods that have Biotoc Index values should be sampled at each site. Sample all suitable habitat at each site no matter how many arthropods are collected.

Sample Handling and Preservation

1. After the sample is collected rinse sediment from the net by forcefully running the net through the water a few times.

2. Visually inspect the net contents to insure that at least 100 arthropods with Biotic Index values were collected. Insufficient numbers may indicate a water quality problem and should be noted.

3. Transfer the debris and arthropods to a wide-mouth jar of sufficient size. Remove any arthropods clinging to the net and include them in the sample. Add enough 70 percent alcohol to the jar to cover the debris (use 95 percent alcohol if enough water remains in the sample to dilute the alcohol to 70 percent).

Field Data

1. Fill out the Macroinvertebrate Field Sampling Data sheet (Form 3200-52) when samples are taken. Use a different sheet at each site within a stream reach.

2. Describe, in detail, the exact location of each sampling site. Use landmarks such as bridges, rock outcroppings, etc. Record distances, directions (east, west -- NOT left, right). Be precise as possible to insure someone else can find the same site in the future.

3. Record water temperature and flow, or stage for future reference.

4. Record sampling methods, i.e., D-frame net, number of replicates, number of transects or other sampling pattern, etc.

5. Record the time spent taking each sample.

6. Record an estimate of the abundance of arthropods at each site as follows:

   Abundant - large number of arthropods found at the site, greater than 1,000 collected in a short time.

   Common - no difficulty in collecting 100 arthropods, sampling resulted in 200 to 1,000 arthropods.

   Uncommon - had difficulty, but managed to collect at least 100 arthropods with Biotic Index values.

   Rare - could not obtain 100 arthropods.