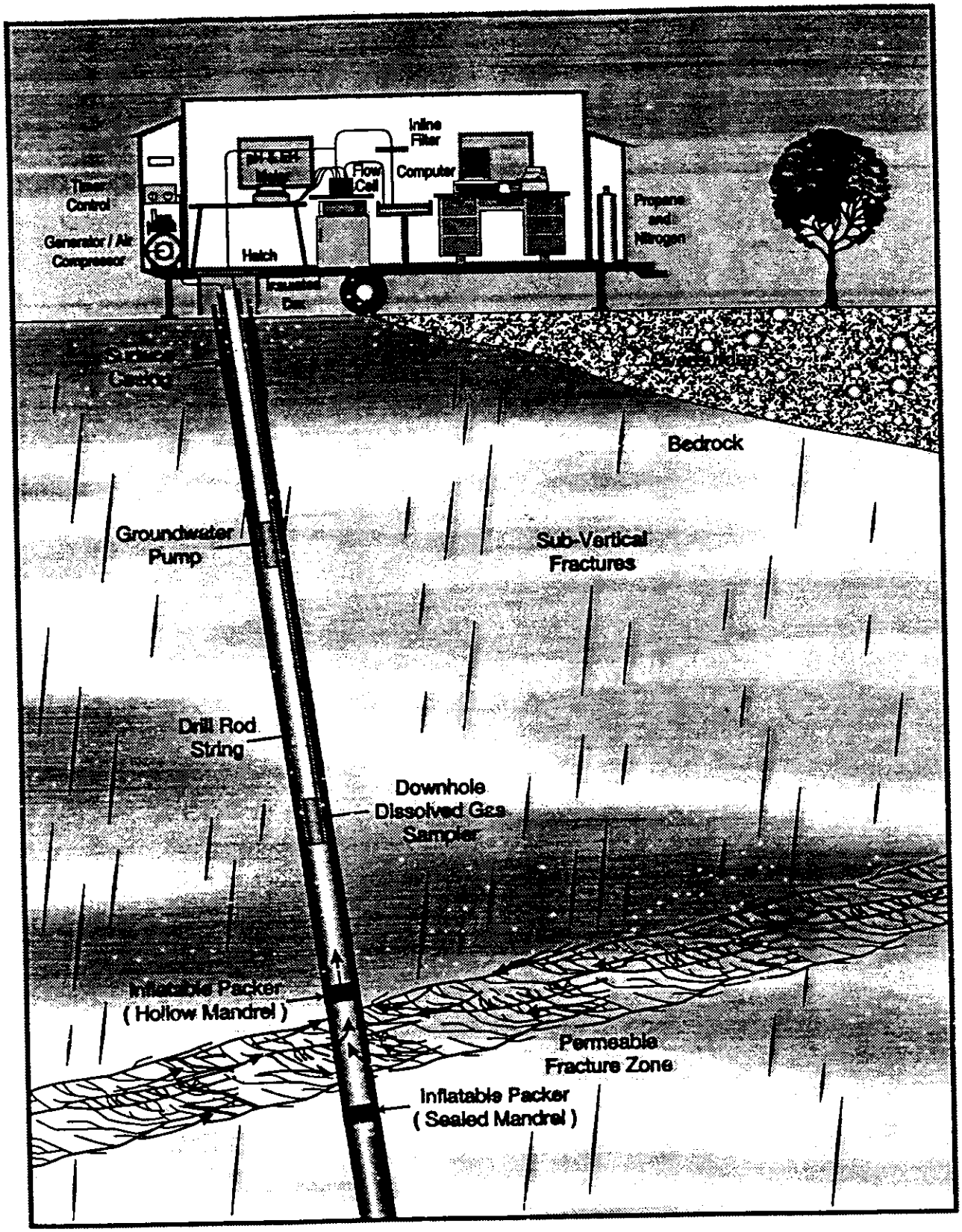
GROUNDWATER SAMPLING

SURFACE COLLARED BOREHOLES:

- *PRODUCTION INFLATION PACKERS (PIPs): used to isolate selected borehole intervals for sample collection;*
- *WESTBAY MP CASING SYSTEMS: water samples collected through piezometer and pumping ports;*
- *AECL MP CASING SYSTEMS: water samples collected from open standpipes*

BOREHOLES COLLARED UNDERGROUND:

- *AECL MP CASING SYSTEMS AND CAPPED BOREHOLES: water samples collected from open standpipes or boreholes*


Inline Filter
Flow Cell
Computer
Timer Control
Generator / Air Compressor
Hatch
Propane and Nitrogen
Bedrock
Groundwater Pump
Sub-Vertical Fractures
Drill Rod String
Downhole Dissolved Gas Sampler
Inflatable Packer (Hollow Mandrel)
Permeable Fracture Zone
Inflatable Packer (Sealed Mandrel)

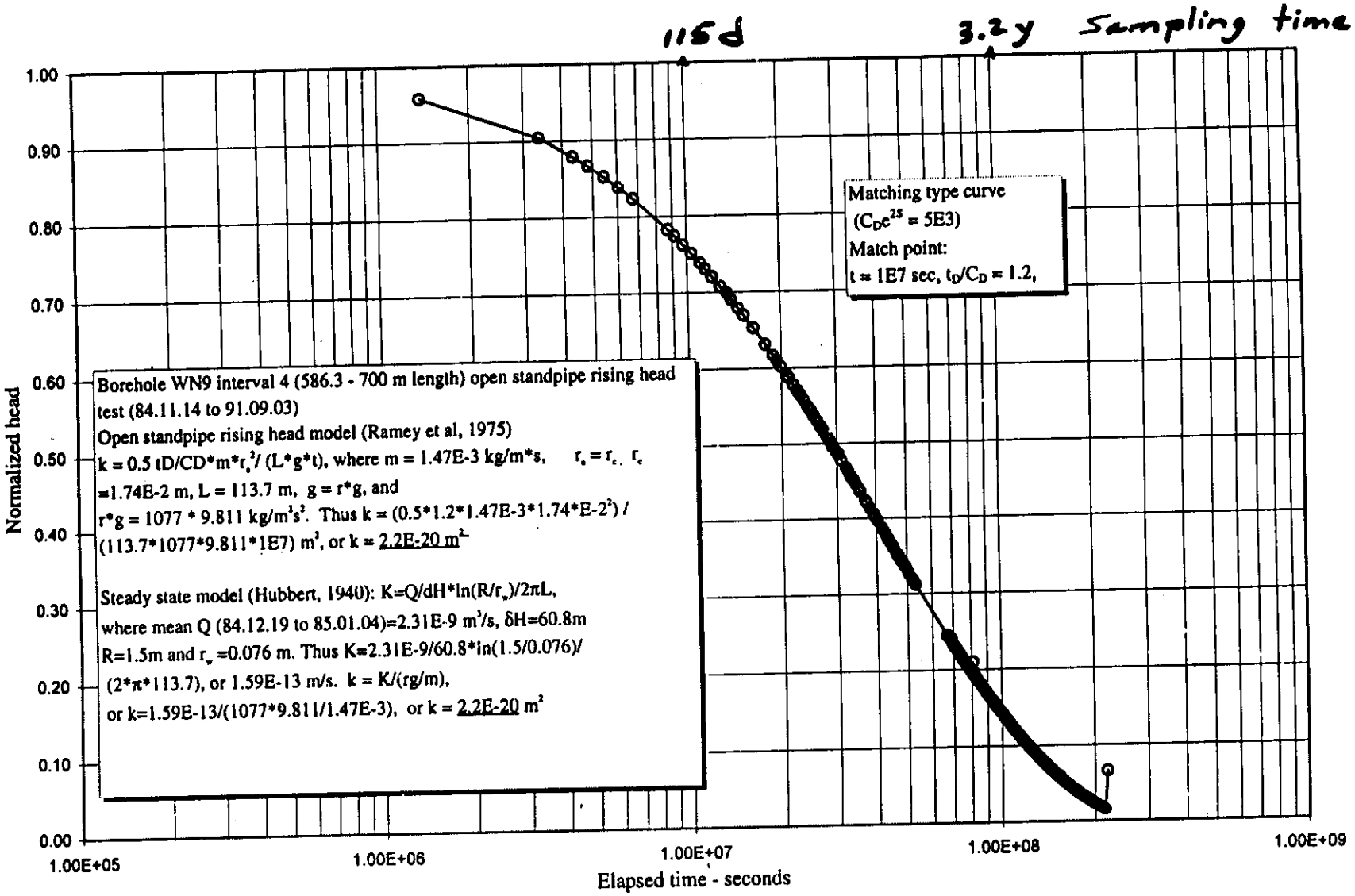


Figure 13: Plot of normalized recovery of WN9 piezometer interval 4 open standpipe water level versus recovery time

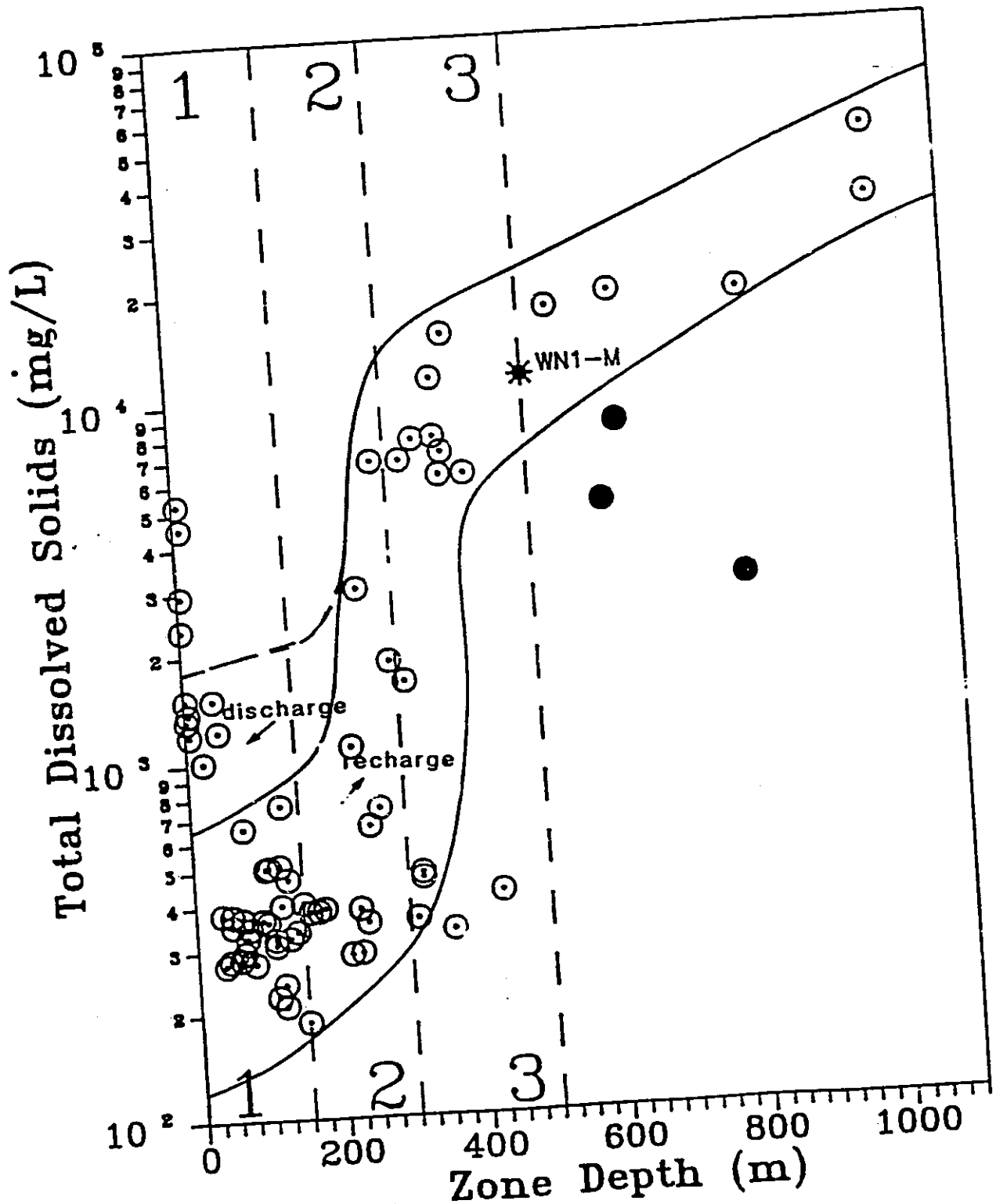
TABLE 6-4

GROUNDWATER SAMPLING, SAMPLE PREPARATION AND ANALYSIS METHODS

Sample	Species/Element	Container	Volume	Filtered	Preservative (Preparation)	Analytical Methods[1]	Laboratory
Anions	HCO_3, SO_4, Cl, Br, F, NO_3, I	Plastic	250 mL	Yes	Refrigerate (4 °C)	Titration, IC Colorimetry	HGC[2]
Cations	Na, Ca, Mg, K, Sr, Si, B	Plastic	125 mL	Yes	4 mL/L HCl	ICPS flame AAS	ASB[3]
Trace elements	Li, Fe, Mn, V, Al + others	Plastic	125 mL	Yes	8 mL/L $HN0_3$	ICPS colorimetry	ASB
Dissolved organic carbon	Organic C	Glass	125 mL	Yes	Refrigerate (Ag)	Infrared analyzer	P. Vilks, GRB[4]
Colloids	Colloidal fractions	Plastic	50 L	No	N_2 purge	Tangential flow	P. Vilks, GRB
Environmental isotopes	^2H, ^3H, ^{18}O; ^3H (enriched)	Plastic Glass	125 mL 1 L	Yes Yes	None None	MS LSC	ASB, Univ of Waterloo
Carbon isotopes	^{13}C, ^{14}C	Plastic	4-100 L	No	None (±PC, $BaCO_3$ or in NaOH)[5]	MS LSC AMS	Univ of Waterloo & Toronto
Sulphur isotopes	$S^{18}O_4$, $^{34}SO_4$	Plastic	1-4 L	Yes	None (PC, ion exchange or $BaSO_4$)[5]	MS	Univ of Waterloo
Chlorine isotopes	^{36}Cl,	Plastic	1-4 L	Yes	None (PC, AgCl)[5]	AMS	Univ of Rochester
Strontium isotopes	$^{87}Sr/^{86}Sr$	Plastic	250 mL	Yes	8 mL/L HNO_3	MS	RH McNutt, McMaster Univ
Uranium and radium isotopes	U, $^{234}U/^{238}U$, ^{226}Ra	Plastic	1-4 L	Yes	8 mL/L HNO_3	AS	HGC
Radon	^{222}Rn	Glass vial	8mL	No	None	LSC	HGC
Dissolved gases	H_2, He, 0_2, N_2, CO_2, CH_4, Ar, H_2S	Steel cylinder	50 mL	No	None	MS	ASB
Dissolved inert gases	He, $^3He/^4He$, Ne isotopes	Copper tube	10 mL	No	None	MS	WB Clarke, McMaster Univ

IC = Ion Chromatography,
ICPS = Inductively Coupled Plasma Spectrometry,
AAS = Atomic Absorption Spectrometry,
(A)MS = (Accelerator) Mass Spectrometry,
LSC = Liquid Scintillation Counting,
AS = Alpha Spectrometry

2 HGC = Hydrogeochemistry Section, AECL, Pinawa
3 ASB = Analytical Science Branch, AECL, Pinawa
4 GRB = Geochemistry Research Branch, AECL, Pinawa
5 PC = Preconcentration (Preparation) done at AECL followed by method used


Total Dissolved Solids (mg/L)
Zone Depth (m)
1
2
3
WN1–M
discharge
recharge
0
200
400
600
800
1000

CANDIDATE AREA CHARACTERIZATION :

- *OPTIMIZING SITE CHARACTERIZATION COSTS*
- *REMOTE SENSING, AIRBORNE SURVEYS, AND RECONNAISSANCE MAPPING*
- *BOREHOLE SITING, DRILLING AND LOGGING,AND TESTING*
- *PIEZOMETER CONSTRUCTION AND MONITORING*
- *GROUNDWATER SAMPLING*
- ***DATA COLLECTION, ANALYSIS AND ARCHIVING***
- *CONCEPTUAL HYDROGEOLOGIC MODEL CONSTRUCTION*

DATA COLLECTION, ANALYSIS AND ARCHIVING

DATA COLLECTION (*QUALITY ASSURANCE FORMAT)*

- *HYDRAULIC TESTING: pressure transmitters, flow computer and thermistors to analog/digital board to master contol computer; linked computer for data analysis, printer/plotter; data loggers*
  - *for interference test boreholes;*
- PIEZOMETRIC LEVEL MONITORING: *pressure transmitters to data loggers or HDAS / UDAS.*

DATA ANALYSIS:

- *HYDRAULIC TESTING: steady state / transient, constant head / flow tests, pulse tests, slug / rising head tests, interference tests.*
- *FRESH WATER HYDRAULIC HEAD: calculations, plots.*
- *HYDROSTRATIGRAPHIC UNITS: geologic logs; geophysical logs; borehole hydraulic test data; hydraulic head plots.*

DATA ARCHIVING:

- *BACKUP; weekly computer files, reports and hardcopy (maps, files)*

TABLE A2

TEST INJECTION INFORMATION SHEET

AECL SINGLE HOLE HYDRAULIC TESTING PROGRAM

FIELD NOTES: Test Information DATE: May 25, 1992

AECL SITE: URL - Boggy Creek AECL HYDROGEOLOGIST: Rod Broadfoot
BOREHOLE: URL-15 TEST INTERVAL: 260 - 408 m.
TEST TYPE: Constant Flow DATA FILE NAME: U15O02BP
TEST INSTRUCTION FORM REFERENCE NO: ------

TEST PLAN:

1) INJECTION TEST X DRAWDOWN TEST _____

PULSE: _____ psi _____ m. SLUG: _____ psi _____ m
CONSTANT HEAD: _____ psi _____ m
CONSTANT FLOW: 18463 ml/min 3.077 E-4 m^3/sec
TEST DURATION: 11100 sec 185 min. 3.0833 hrs

2) RECOVERY DURATION

SLUG:	_____ sec	_____ min	_____ hrs
PULSE:	_____ sec	_____ min	_____ hrs
CONSTANT HEAD:	_____ sec	_____ min	_____ hrs
CONSTANT FLOW:	11100 sec	185 min	3.0833 hrs

TEST NOTES

1) INJECTION TEST: X DRAWDOWN TEST: _____

MAX. FLOW CHANGE DURING CONSTANT HEAD TEST: _____ ml/min
MAX. HEAD CHANGE DURING CONSTANT FLOW TEST: 2.38 PSI 1.673 Meters

2) EQUIPMENT OPERATION:

PACKERS: 500 psi OVER-PRESSURE
QA VALVE: OK. OPEN TO START
DOWNHOLE D.A. SYSTEM: WESTBAY TRANSDUCER #003
UPHOLE D.A. SYSTEM: COMPAQ 286, ACjr A/D BOARD, FLOW COMPUTER FC-81
WATER INJECTION: FLOW TURBINE FT-10
ZONE TEMPERATURE: START TEST: 1.409 V 10.5° C.
END TEST: 1.410 V 10.7° C.

3) GENERAL COMMENTS:

URL-14 UPPER ZONE - NO RESPONSE
URL-14 LOWER ZONE - 37 mm RESPONSE
EQUIPMENT FUNCTIONING NORMAL

TABLE A3

INJECTION INFORMATION SHEET

AECL SINGLE HOLE HYDRAULIC TESTING PROGRAM

FIELD NOTES: Test Information DATE: May 25, 1992

AECL SITE: URL Boggy Creek AECL HYDROGEOLOGIST: Rod Broadfoot
BOREHOLE: URL-15 TEST INTERVAL: 260 - 408 m.
TEST TYPE: Constant Flow DATA FILE NAME: U15O02BP
TANK CALIBRATION: 76.92 ml/mm

1) SYSTEM TEST

a) Leak Test

Pressure	Tank Level (mm)		Volume Used		Leakage Rate	
(psi)	Start	Finish	(mm)	(ml)	(ml/min)	---
30						---
90						---
150					No Leakage	---

b) Time vs. Flowrate & Pressure

(See Table and Graph) N/A

2) SYSTEM OPERATION

INJECTION DURATION: 11100 sec 185 min 3.0833 hrs
WATER QUALITY: Temp. 10°C. Conductivity 120 mS/cm²
TANK LEVEL: Start _____ mm Finish _____ mm Total _____ mm
VOLUME INJECTED: _____ mm x 76.92 ml/min = _____ ml
VOLUME CHECK: Q _____ ml/min x _____ min = _____ ml
ROSEMOUNT D.P. TRANS: Not Used mm Volume _____ ml
CALCULATED Q: Vol _____ ml/_____ min = _____ ml/min

Time	Flowrate (ml/min)		System Pressure (psi)	
(sec)	Gross	Net	Tank	Injection
1000		18500		
12100		18346		
		Total Volume -		
		3011.56 L		

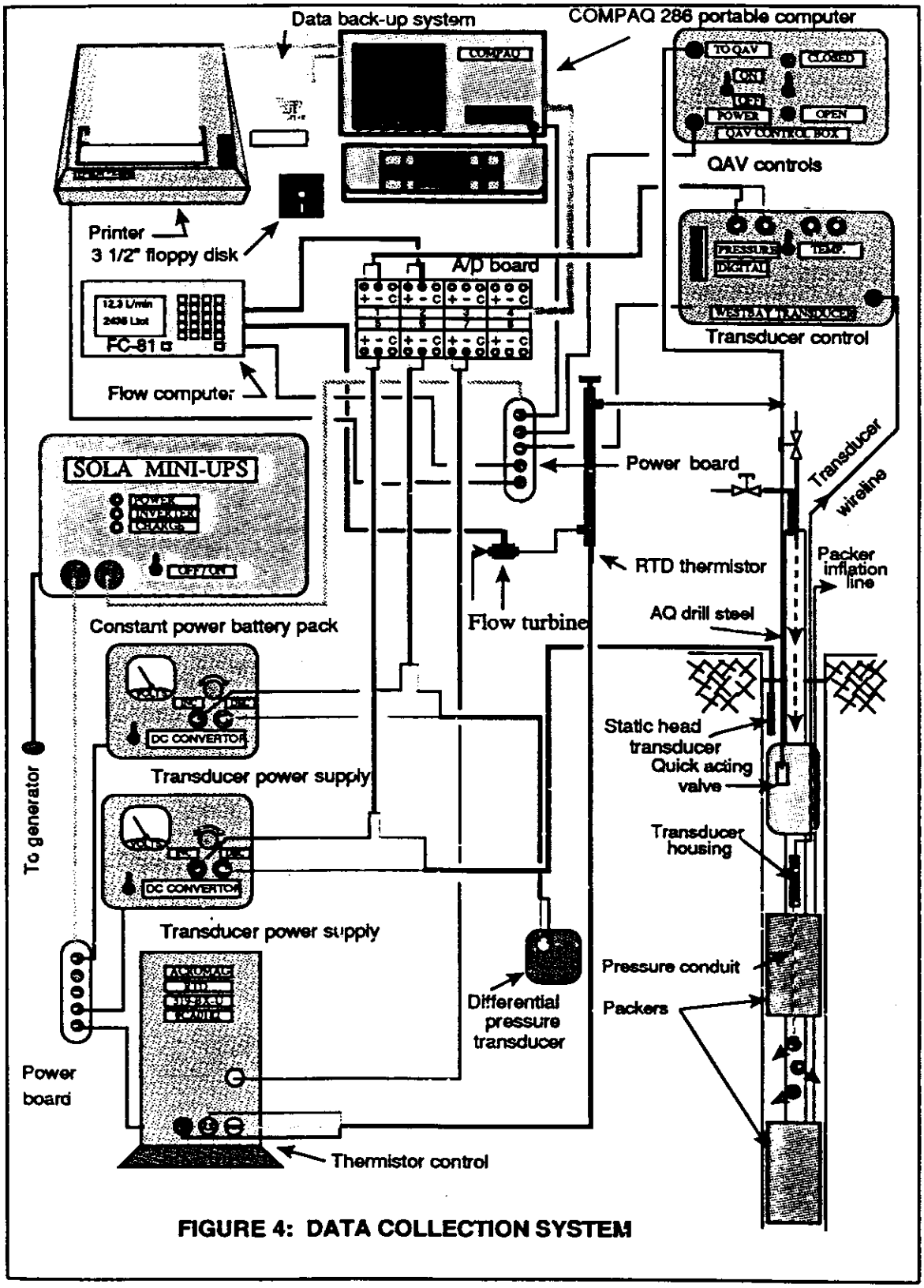


FIGURE 4: DATA COLLECTION SYSTEM

8. DATA COLLECTION FLOW CHART

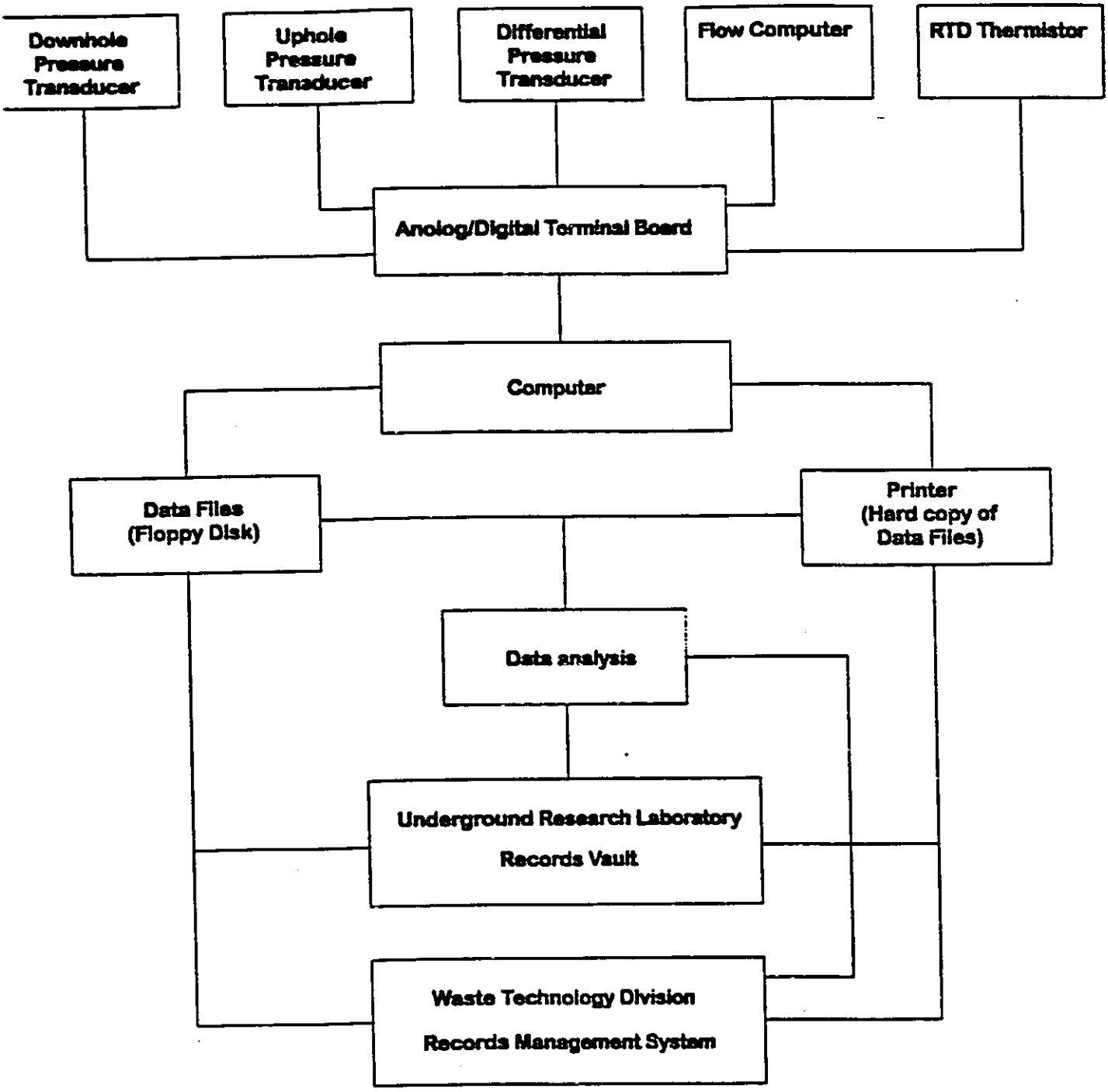
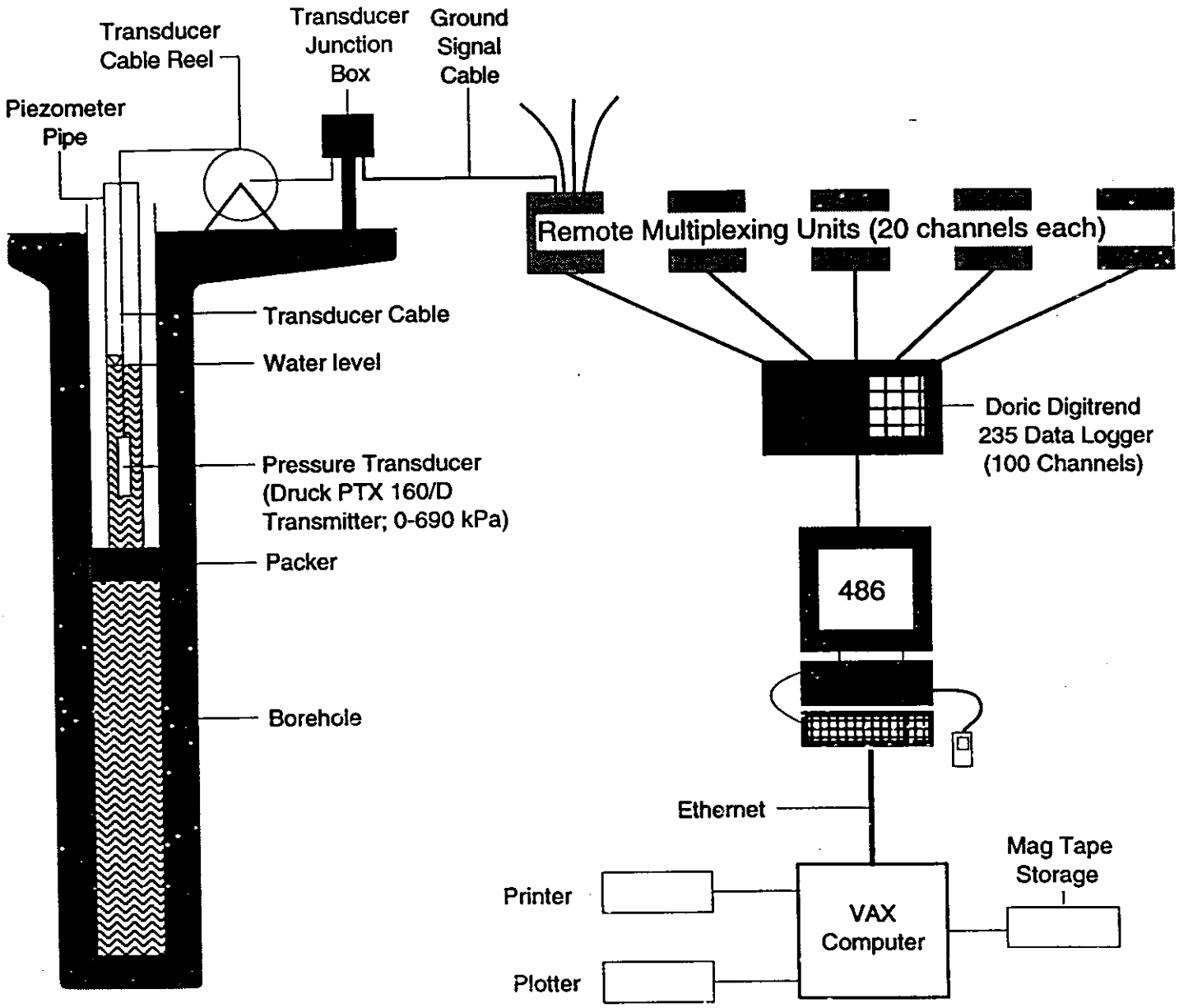


FIGURE A27: Flow Chart Showing the Data Collection Path

Hydrogeology Data Acquisition System (HDAS)
Surface Boreholes



Number of Channels Presently Scanned

77

Scan Rates: Normal - 1 Scan per hour

Fast - 1 Scan per minute

CANDIDATE AREA CHARACTERIZATION :

- *OPTIMIZING SITE CHARACTERIZATION COSTS*
- *REMOTE SENSING, AIRBORNE SURVEYS, AND RECONNAISSANCE MAPPING*
- *BOREHOLE SITING, DRILLING AND LOGGING,AND TESTING*
- *PIEZOMETER CONSTRUCTION AND MONITORING*
- *GROUNDWATER SAMPLING*
- *DATA COLLECTION, ANALYSIS AND ARCHIVING*
- ***CONCEPTUAL HYDROGEOLOGIC MODEL CONSTRUCTION***

CONCEPTUAL HYDROGEOLOGIC MODEL CONSTRUCTION:

- *CONCEPTUAL MODEL SCALE AND BOUNDARY CONDITIONS*
- *HYDROSTRATIGRAPHIC UNIT CHARACTERISTICS*
- *HYDRAULIC HEAD DISTRIBUTION*
- *MATHEMATICAL MODEL REQUIREMENTS*

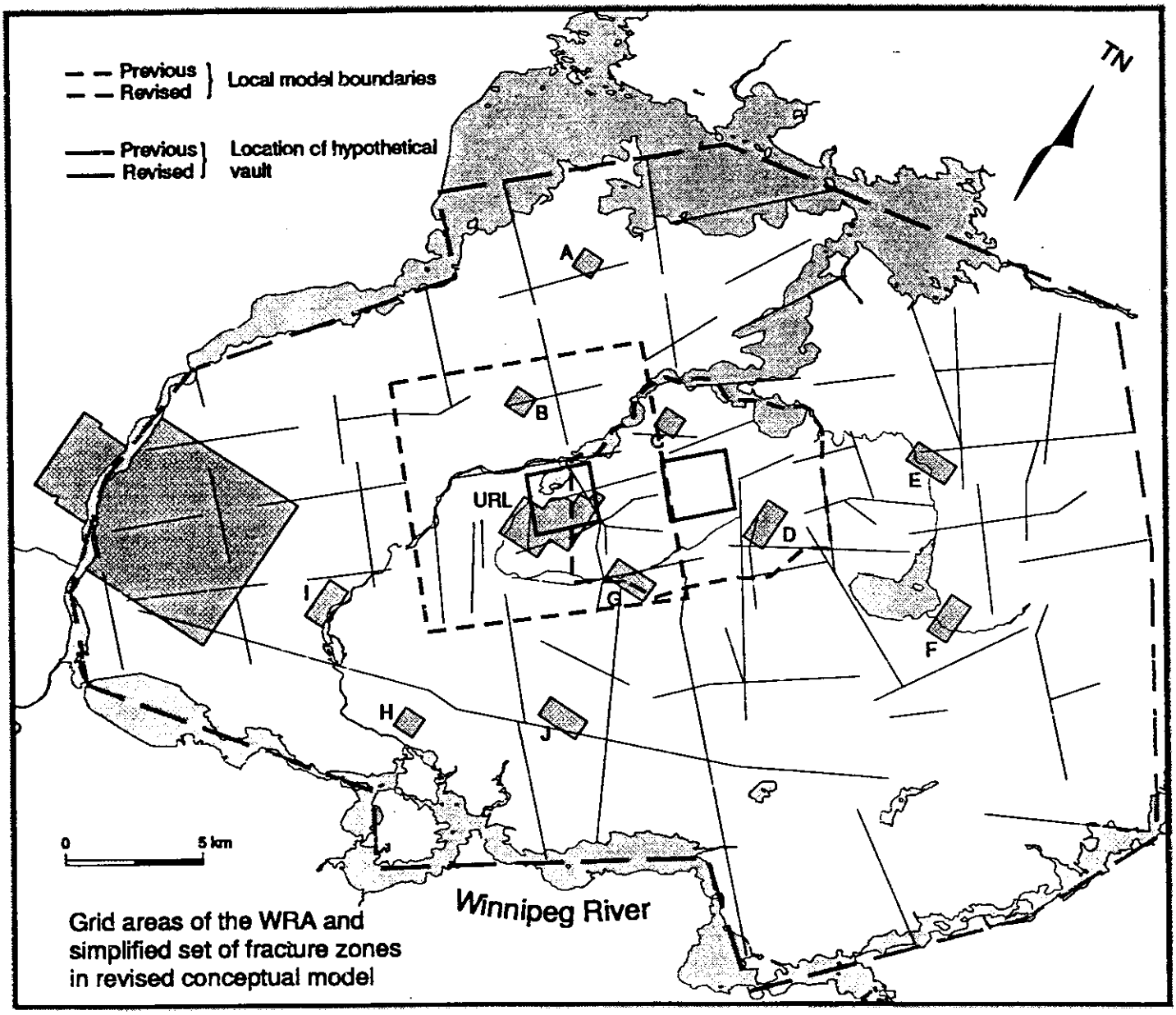
CONCEPTUAL MODEL SCALE AND BOUNDARY CONDITIONS

CONCEPTUAL MODEL SCALE:

- *REGIONAL: to include the boundaries of the selected Candidate Areas (> 400 km^2);*
- *LOCAL: to include the boundaries of the selected Candidate Sites (~ 25 km^2)*

CONCEPTUAL MODEL BOUNDARY CONDITIONS:

- *REGIONAL: to coincide with regional catchment boundaries around the selected Candidate Areas;*
- *LOCAL: to coincide with the boundaries of the selected Candidate Sites (to be selected from the mathematical hydrogeologic model)*



Grid areas of the WRA and simplified set of fracture zones in revised conceptual model

HYDROSTRATIGRAPHIC UNIT CHARACTERISTICS

HYDROSTRATIGRAPHIC UNITS: are geologic domains with similar hydraulic properties

HYDRAULIC PROPERTIES:

PERMEABILITY; m^2

EFFECTIVE POROSITY: drainable rock-mass pore volume / total rock-mass volume

COMPRESSIBILITY: 1 / Pa, or m^2 / N

GEOMETRY: *REGIONAL SCALE : hydrostratigraphic units extend for 1000s to 10 000s m (across Candidate Area);*

LOCAL SCALE (FAR FIELD): hydrostratigraphic units extend for10s to 100s m (across Candidate site);

LOCAL SCALE (NEAR FIELD): hydrostratigraphic units extend for1 to 10s m

WD3 GEOPHYSICAL AND FRACTURE LOGS AND FRACTURED ROCK TYPE

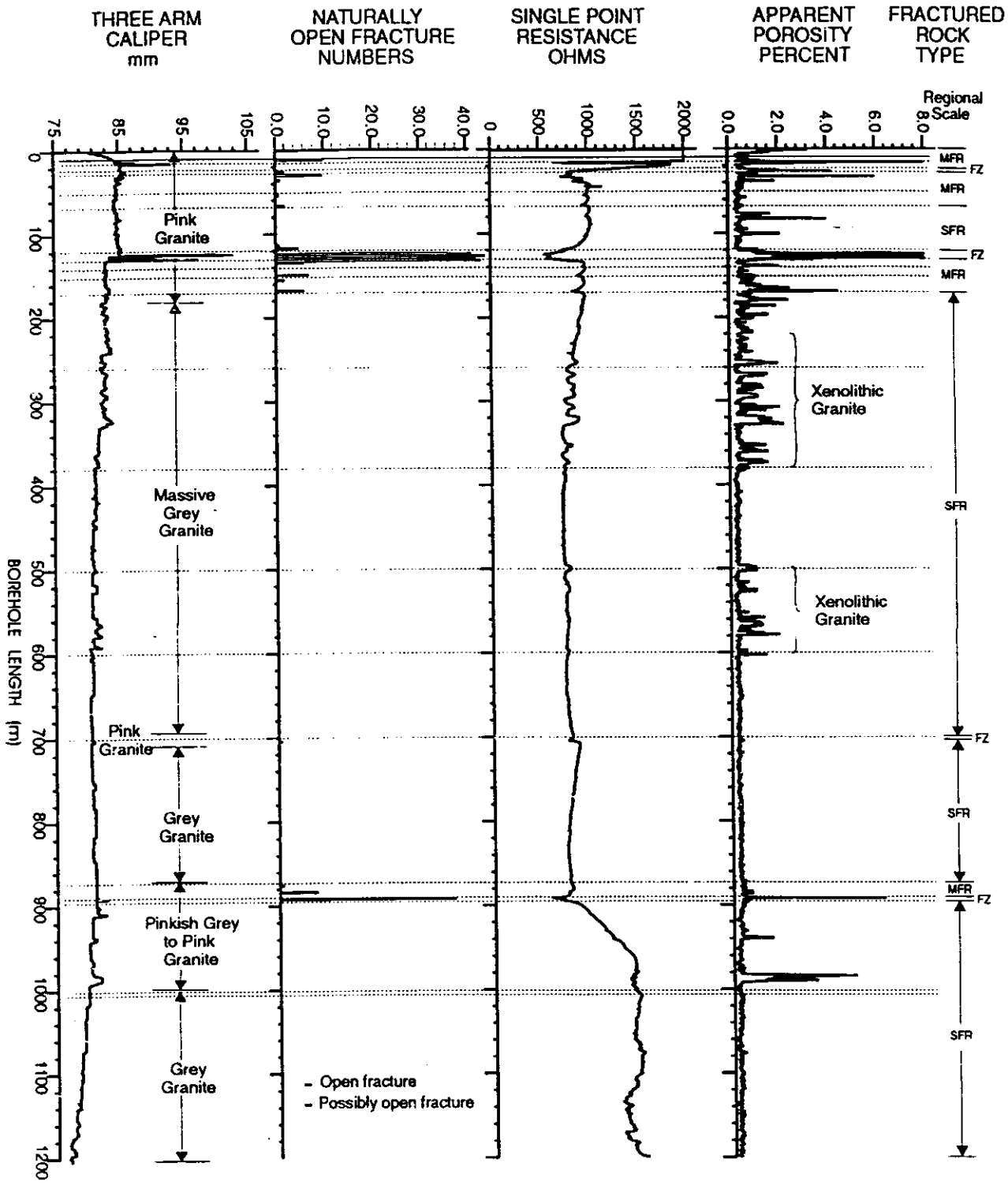


Figure 4: Selected Geophysical Signatures of Logged-Open Fractures and Fractured Rock Domains in Borehole WD3

WG4 GEOPHYSICAL AND FRACTURE LOGS AND FRACTURED ROCK TYPE

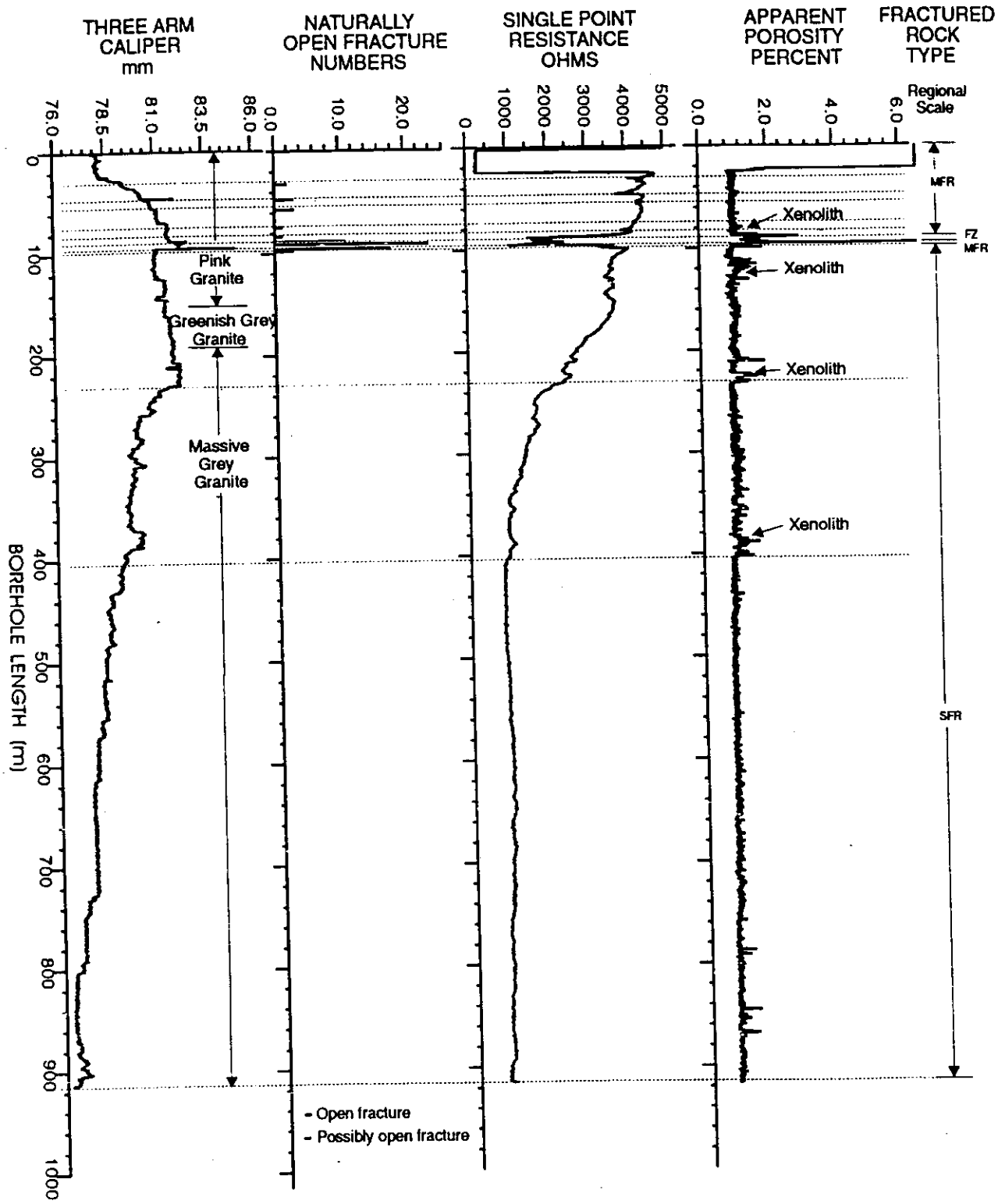
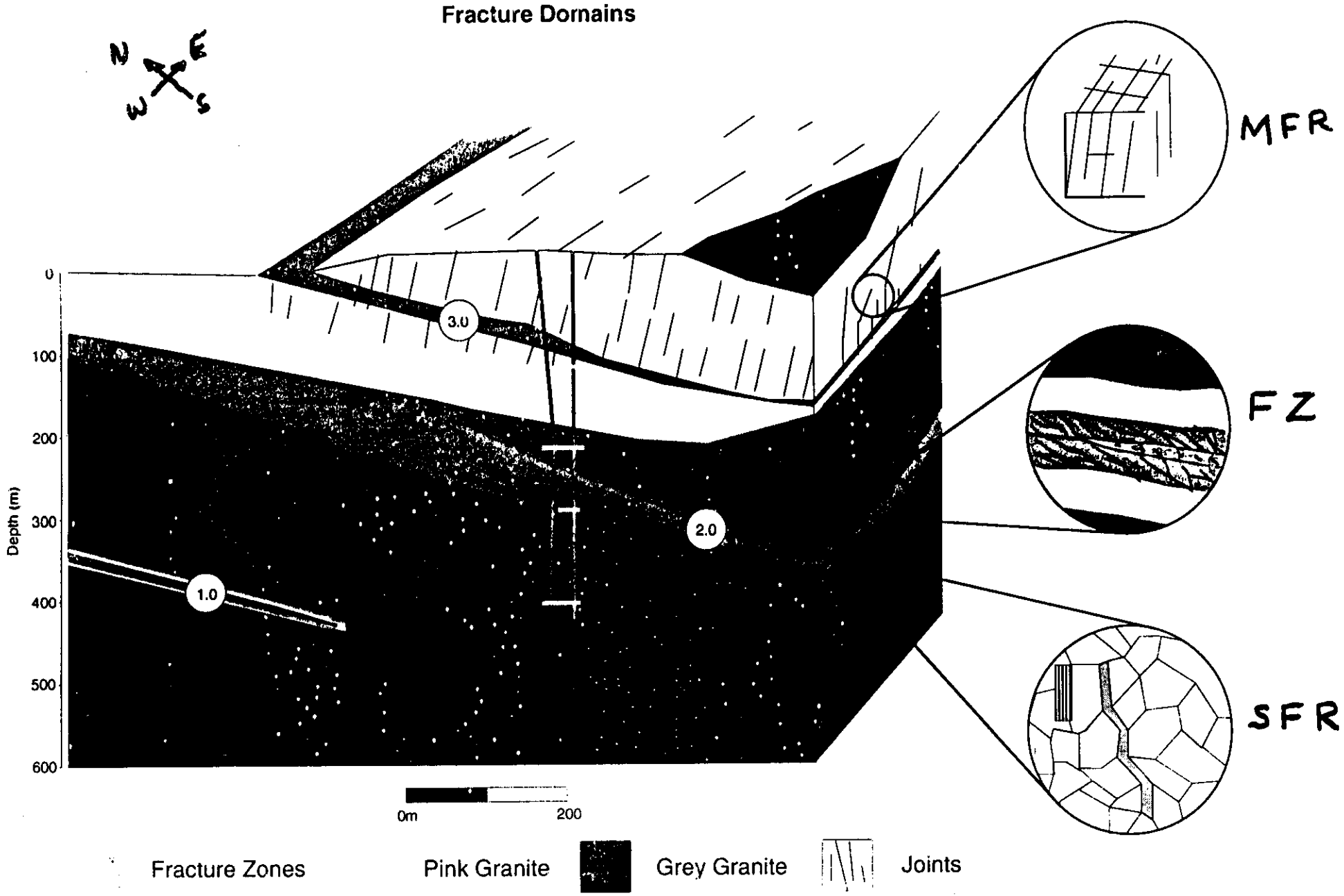


Figure 5: Selected Geophysical Signatures of Logged-Open Fractures and Fractured Rock Domains in Borehole WG4


Fracture Domains
N
E
W
S
MFR
FZ
SFR
3.0
2.0
1.0
Depth (m)
0
100
200
300
400
500
600
0m
200
Fracture Zones
Pink Granite
Grey Granite
Joints

HYDRAULIC HEAD DISTRIBUTION

UPPER BOUNDARY: *STEADY STATE (specified head: Dirichlet);*

TRANSIENT (specified flux: Neumann)

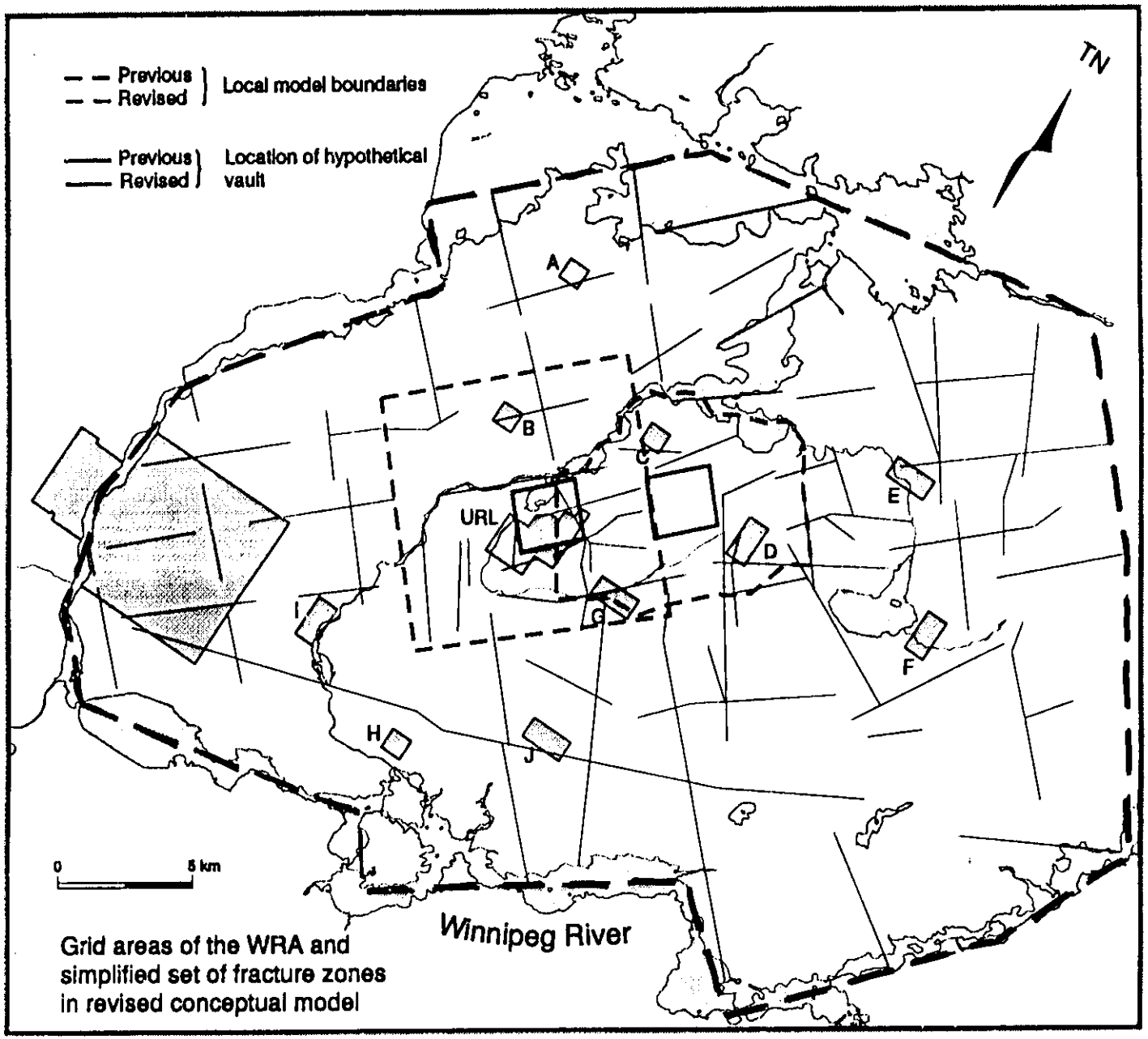
LATERAL BOUNDARY:

SPECIFIED HEAD (Dirichlet condition);

SPECIFIED FLOW (Neumann condition);

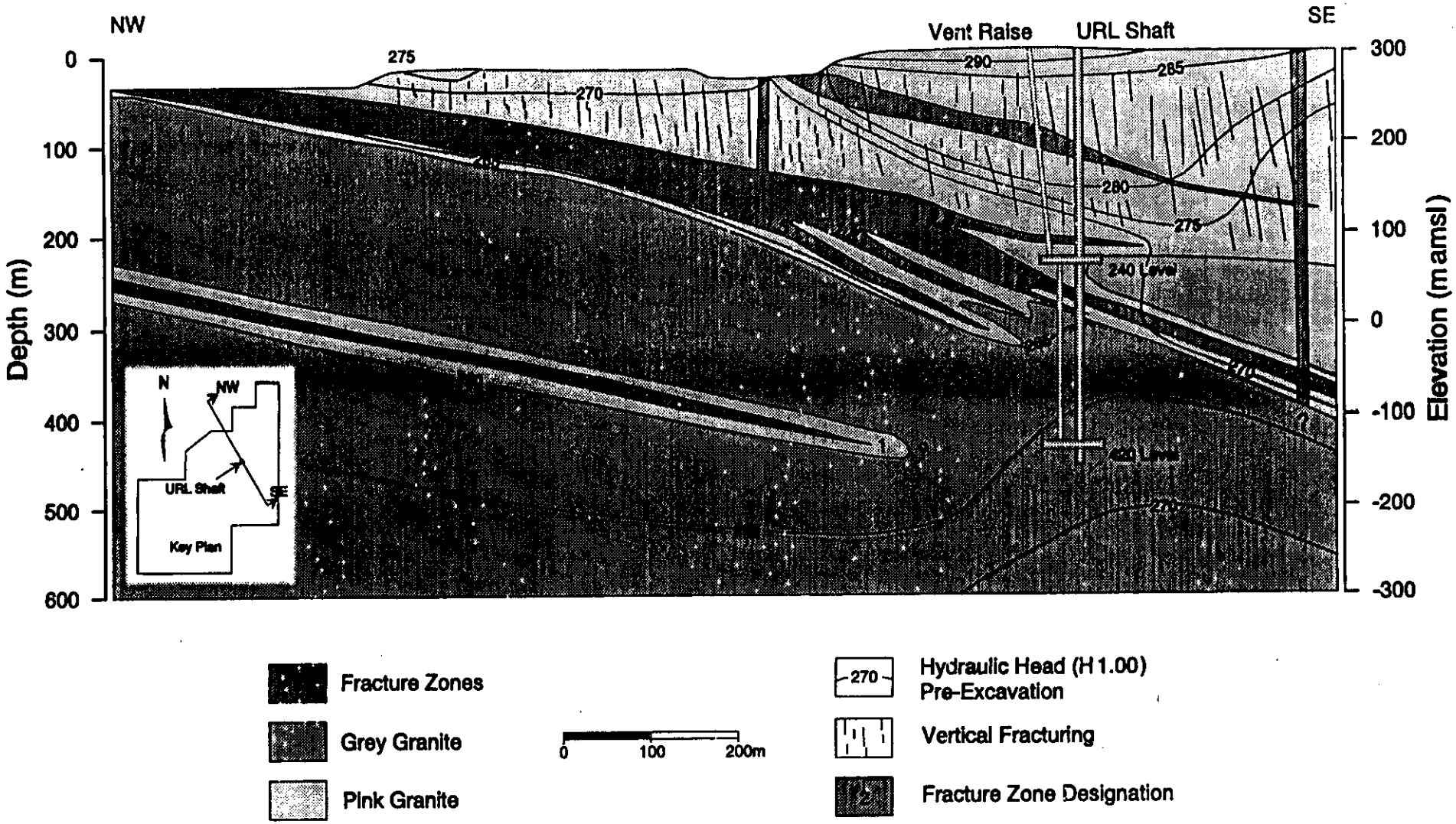
MIXED (combination of both)

LOWER BOUNDARY: *NO FLOW (permeability barrier)*



Grid areas of the WRA and simplified set of fracture zones in revised conceptual model


N
A
A'
(m.a.s.l.)
300.000
295.000
290.000
285.000
280.000
275.000
270.000
265.000
260.000
255.000
250.000


NW
SE
Vent Raise
URL Shaft
275
270
290
285
280
275
240 Level
420 Level
270
0
100
200
300
400
500
600
Depth (m)
300
200
100
0
-100
-200
-300
Elevation (m amsl)
N
NW
URL Shaft
SE
Key Plan
Fracture Zones
Grey Granite
Pink Granite
0
100
200m
270
Hydraulic Head (H1.00)
Pre-Excavation
Vertical Fracturing
Fracture Zone Designation

MATHEMATICAL MODEL REQUIREMENTS

MODEL GEOMETRY: *STEADY STATE; TRANSIENT*

MODEL GEOMETRY:

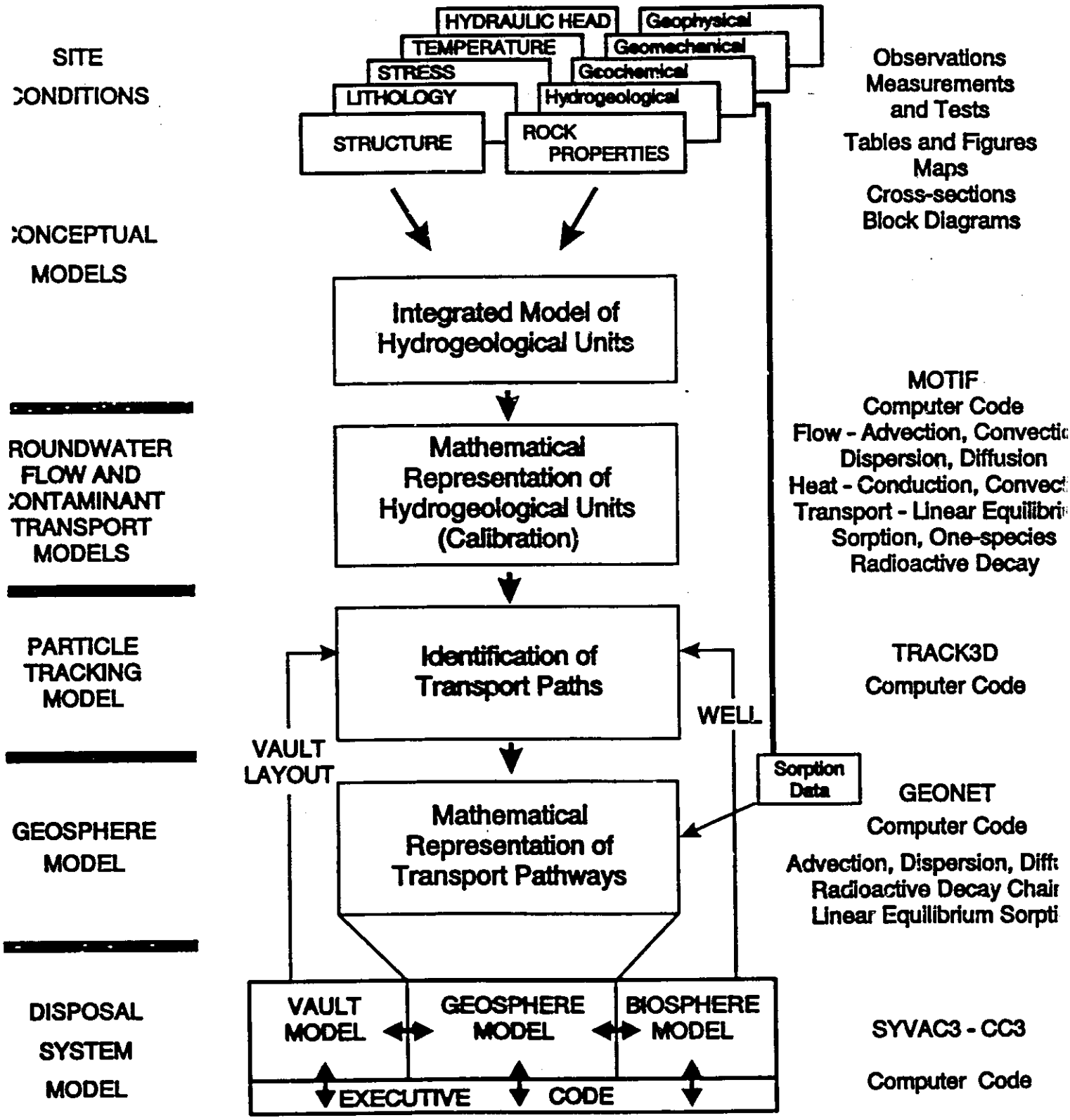
- *Boundaries coincide with conceptual model;*
- *model layering coincides with hydrostratigraphic units given in conceptual hydrogeologic model.*

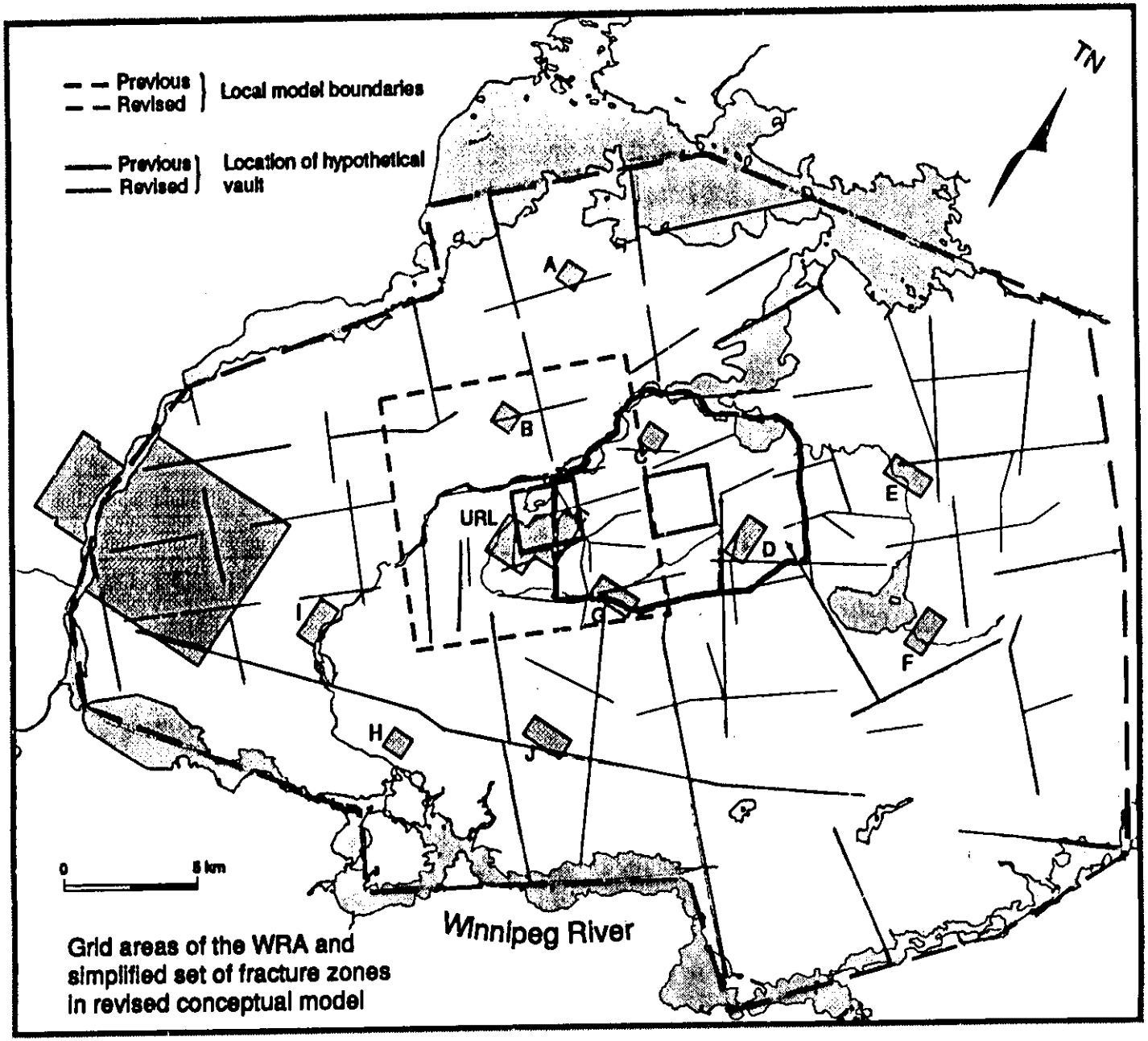
MODEL COMPONENTS: *solid elements representative of the rock mass;*
planar elements representative of the fracture zones (FZs);
rod-shaped elements representative of fracture zone intersections or channels within FZs where required.

CODE: *AECL uses the 3 - D finite element code MOTIF which simulates the coupled processes of:*

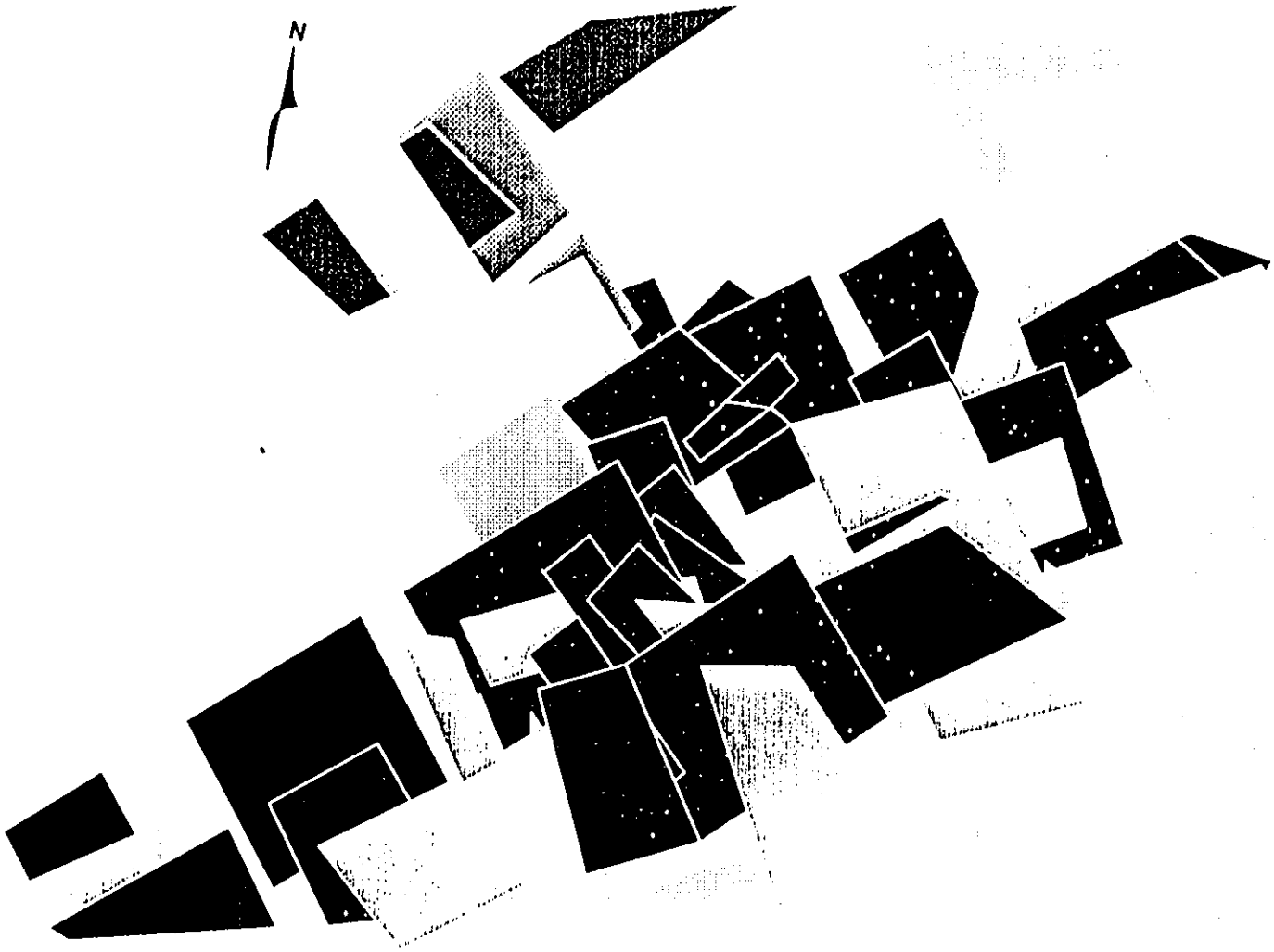
groundwater flow;
heat transport;
and solute transport

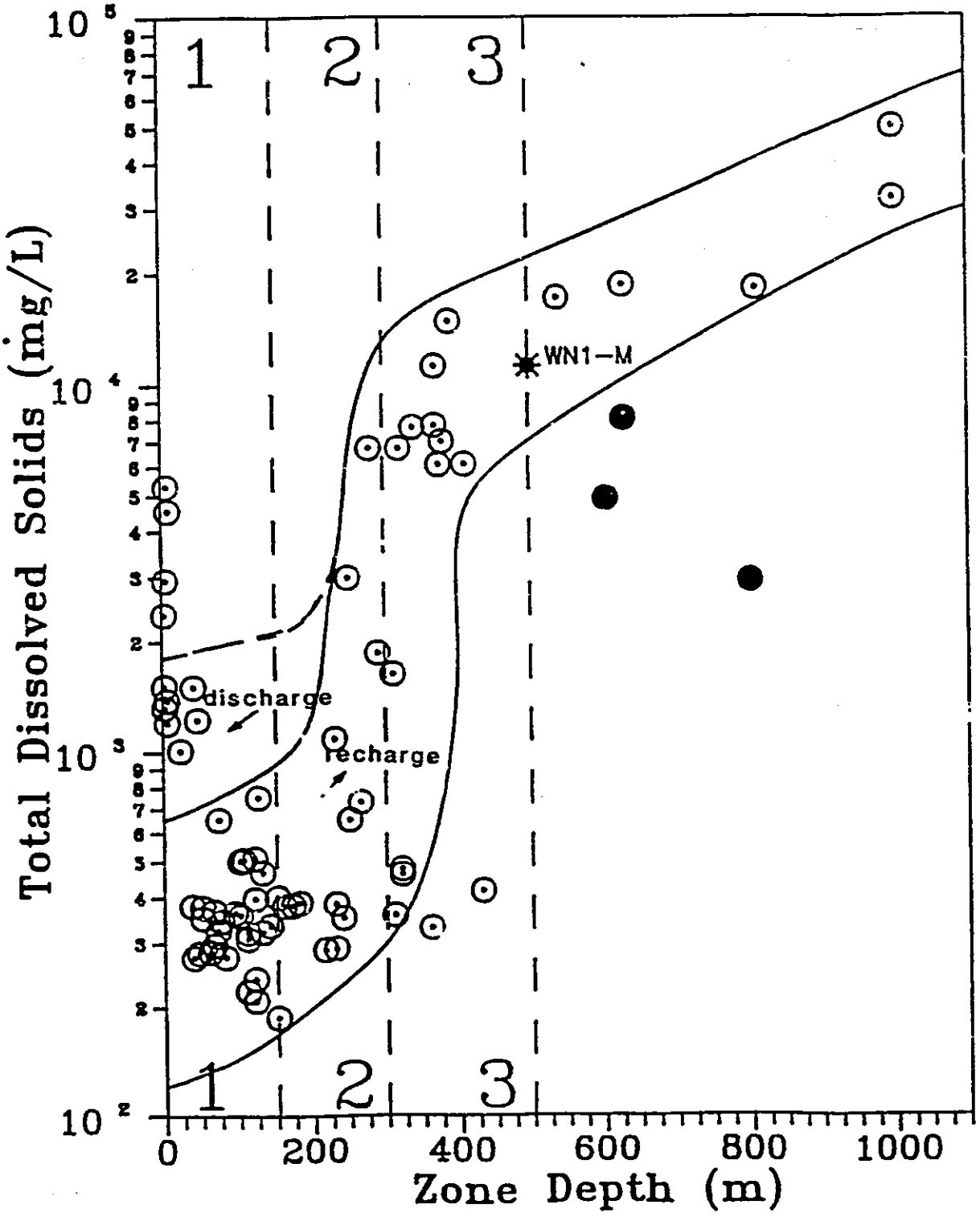
GEOSPHERE MODELLING APPROACH

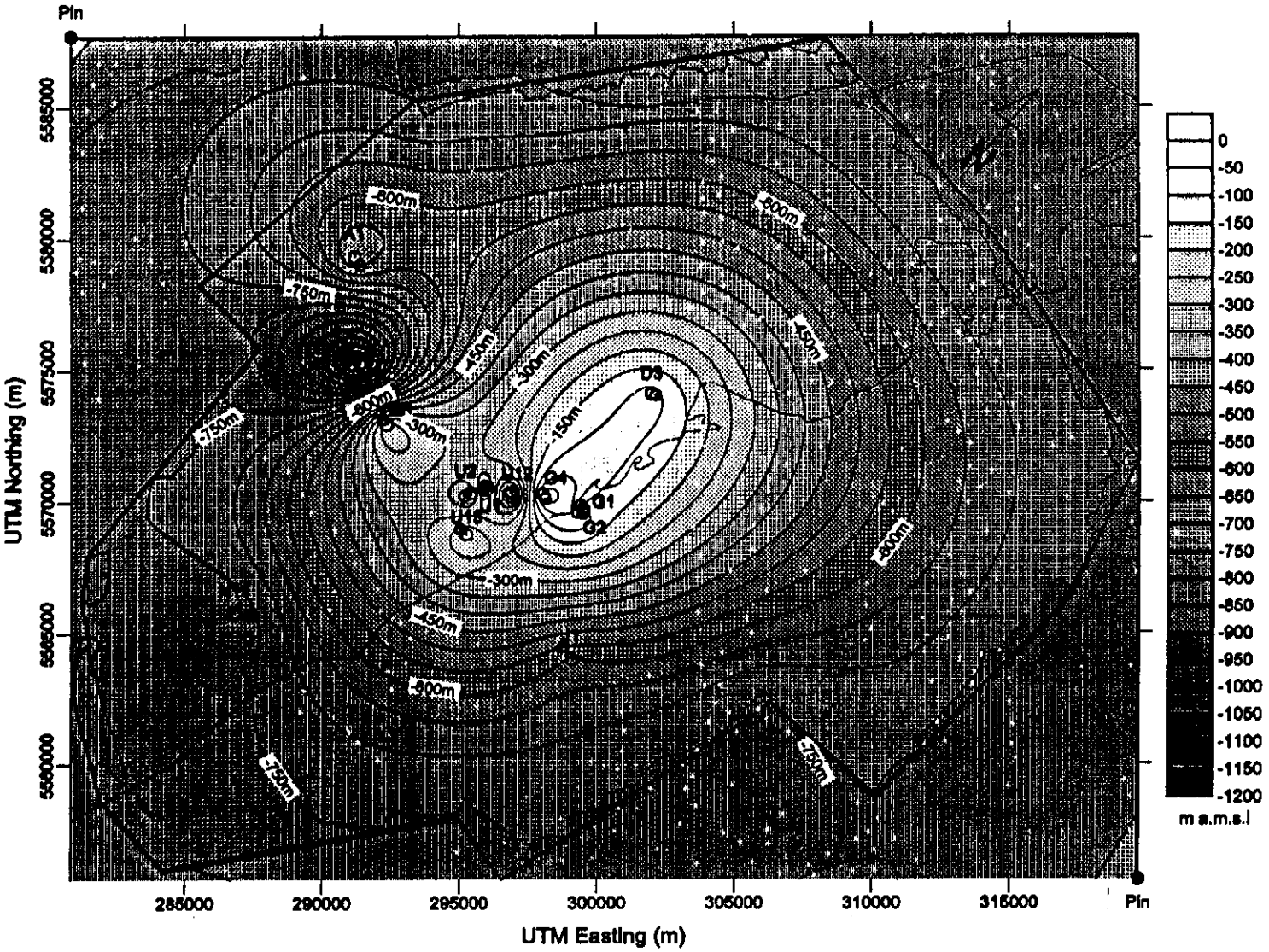




Grid areas of the WRA and simplified set of fracture zones in revised conceptual model


N


Total Dissolved Solids (mg/L)
Zone Depth (m)
1
2
3
WN1—M
discharge
recharge
0
200
400
600
800
1000



Notes: Black circles are borehole collars, and blue circles are the borehole intersections with sparsely fractured rock domain projected to ground surface

Figure 5: Structure contour map at the upper surface of the domain of massive sparsely fractured grey granite rock in the Whiteshell research Area (after Figure 12 Ophori et al, 1995)

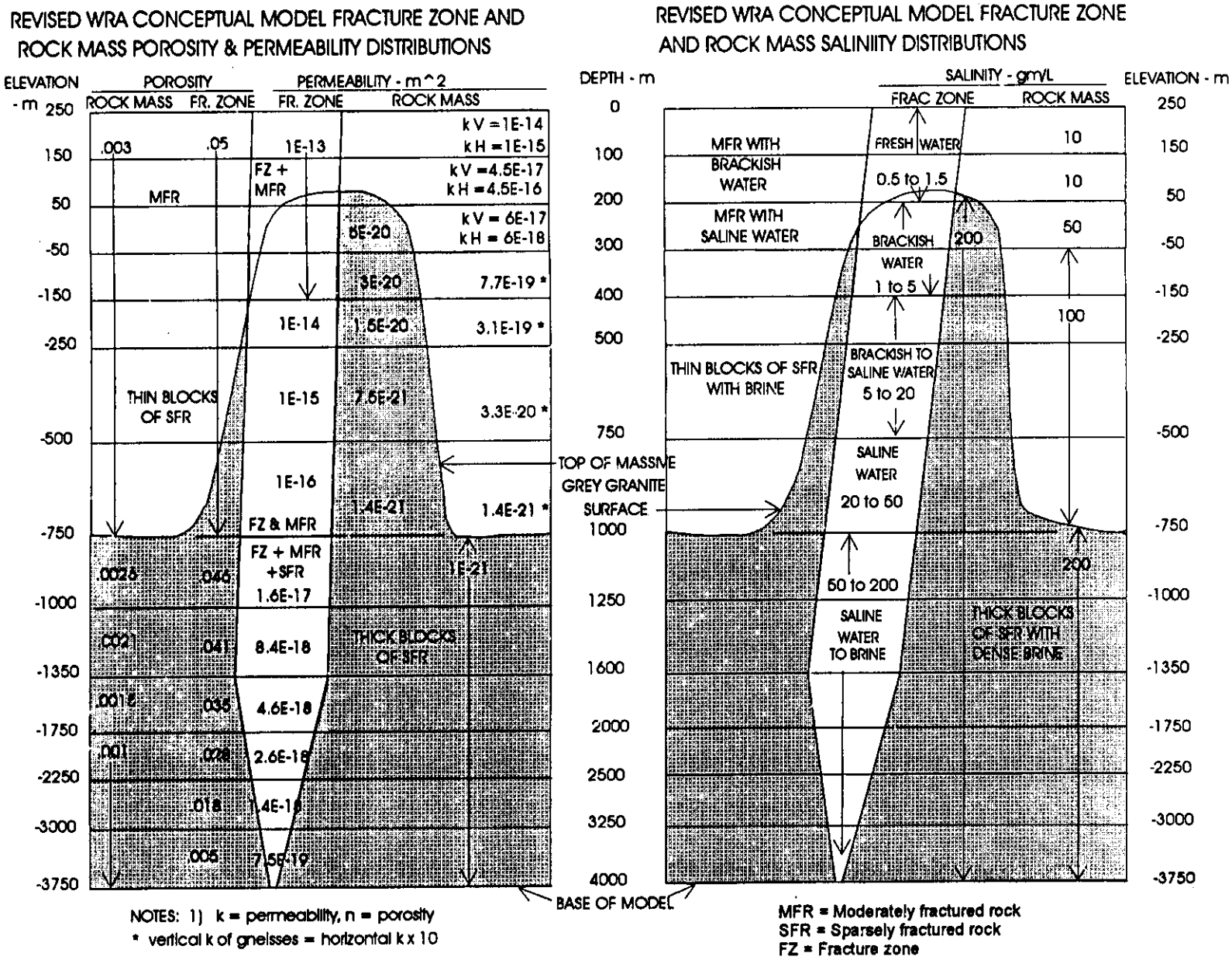
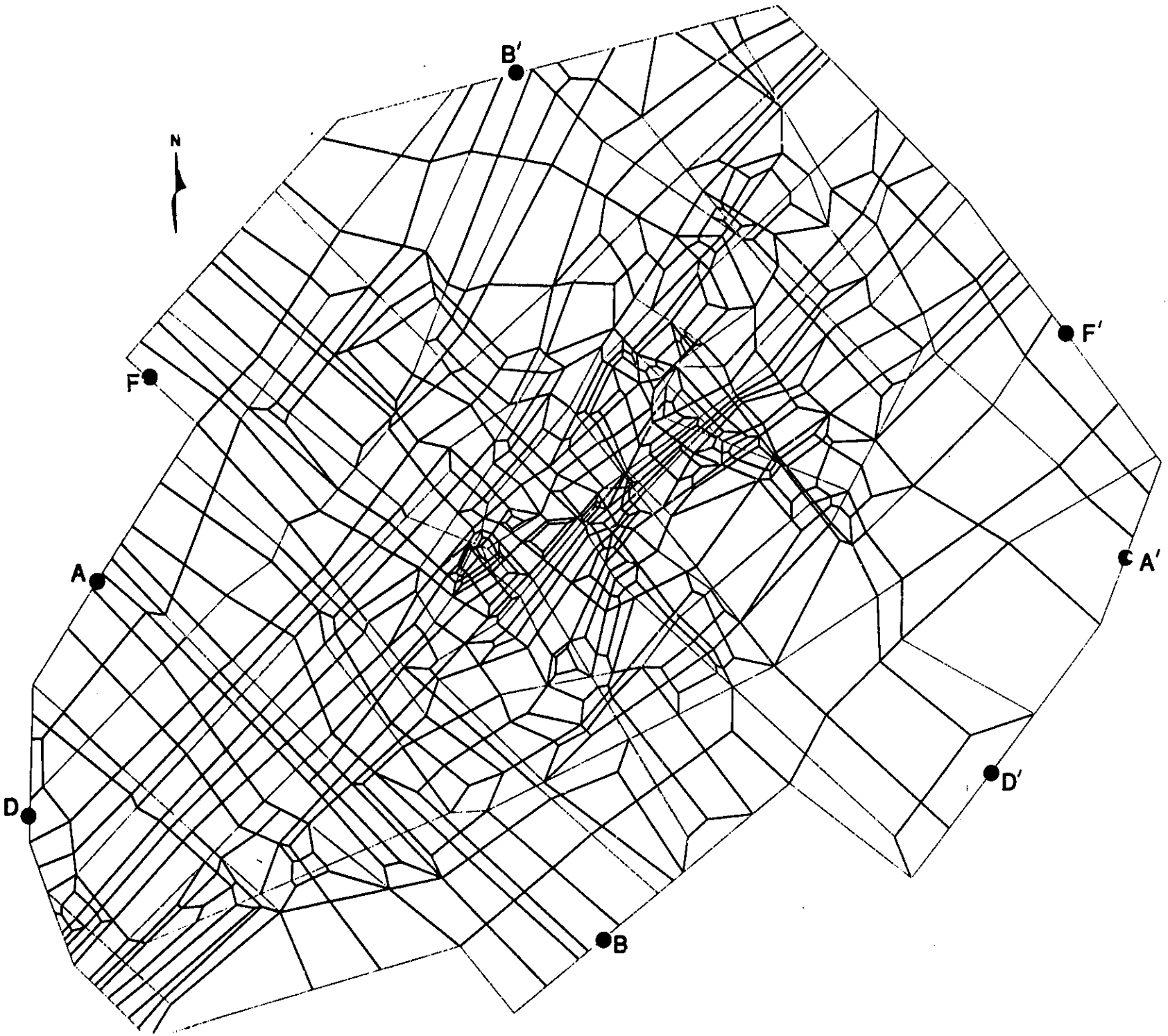


Figure 12: Permeability, Porosity and Salinity Distributions in the Revised Conceptual Hydrogeologic Model


B′
N
F′
F
A
A′
D
D′
B

HYDROGEOLOGICAL ASPECTS:

- *HOST AREA SCREENING*
- *POTENTIAL CANDIDATE AREA EVALUATION*
- *CANDIDATE AREA CHARACTERIZATION*
- ***FAVOURABLE CANDIDATE SITE CHARACTERISTICS***
- *CANDIDATE SITE CHARACTERIZATION*
- *RESEARCH AND DEVELOPMENT*

FAVOURABLE CANDIDATE SITE CHARACTERISTICS

- *LARGE REGIONS OF LOW PERMEABILITY ROCK BELOW 500 M*
- *LONG NATURAL GROUNDWATER FLOW PATHWAYS FROM BELOW 500 M DEPTH AND GROUND SURFACE*
- *VERY REDUCING GROUNDWATER CONDITIONS*
- *LOW HORIZONTAL INSITU STRESS AND H:V STRESS RATIO*
- *ABSENCE OF OVERLYING DEEP HIGH-YIELD WATER WELLS*
- *BELOW FRESH WATER / SALT WATER INTERFACE*

HYDROGEOLOGICAL ASPECTS:

- *HOST AREA SCREENING*
- *POTENTIAL CANDIDATE AREA EVALUATION*
- *CANDIDATE AREA CHARACTERIZATION*
- *FAVOURABLE CANDIDATE SITE CHARACTERISTICS*
- ***CANDIDATE SITE CHARACTERIZATION***
- *RESEARCH AND DEVELOPMENT*