NORGES GEOLOGISKE UNDERSØKELSE

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RAPPORT

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Tittel:
Brønnboringsteknologi og kartlegging, opprensking av forurenset grunn. Rapport fra studiereise i USA juni 1989.

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Sammendrag:

En studiereise til USA juni 1989 ble foretatt for å vurdere brønnboringsteknologi og kartlegging, opprensking av forurenset grunn med spesialavfall. Det konseptet en benytter seg av i Norge på brønnboringssiden er et konkurransedyktig produkt sammenlignet med vanlig praksis i USA. Spesielt mobilitet, pris og tidsforbruk er bedre etter norsk praksis. Innen forurenset grunn, kartlegging, opprydding satses det enorme beløp i regi av føderale SUPERFUND, men også i statlige programmer. Det er et stort behov for en videre utvikling på spesielt prøvetakere av jord.

Emneord Brønnboring	Hydrogeologi	Deponi
Forurenset grunn	Spesialavfall	

INNHOLD

FORORD

En studiereise ble foretatt i juni 1989 for å skaffe oversikt og status for arbeidet innen brønnboringsteknologi samt kartlegging, opprensking av forurenset grunn med eksempel fra Oregon.

Reisen ble finansiert av NTNF og NGU.

INNLEDNING

Ved Norges geologiske undersøkelse (NGU) har en sett et behov for å videre-utvikle brønnboringsteknologi og kompetanse omkring etablering av borebrønner i fjell og løsmasser for vannforsyning, samt i tilknytning til forurensnings-undersøkelser.

NGU ønsker å gå sterkere inn for å bidra til en slik utvikling både på teknologi- og kompetansesiden. En ønsker å ta initiativet til et nærmere samarbeid mellom forskningsmiljø, produsent og operatør for å få definert konkrete samarbeidsprosjekter.

Det ble foreslått at samarbeidet skulle inndeles med en forstudie som omfatter en studietur til USA. Studieturen hadde som formål å være en kunnskapsoverføring hvor en bl.a.

- skaffet internasjonal status over brønnboringsteknologi
- vurderte områder for videre utvikling
- vurderte markedspotensialet
- knyttet kontakter innen produsent- og forskningsmiljø i USA

Med grunnlag i forstudien/studieturen er målsettingen å definere konkrete samarbeidsprosjekter som skal utvikle områder innen brønnboringsteknologien nasjonalt.

BAKGRUNN

Det bores årlig ca. 3 - 4 000 borebrønner i Norge, kostnadene knyttet til brønnboring inklusive tilhørende pumpeanlegg beløper seg årlig til mer enn 250 mill NOK. Nærmere 20% av Norges befolkning benytter seg idag av grunnvann som drikkevann.

I den seinere tid har det skjedd en progressiv overgang fra overflatevannkilder til grunnvann i vannforsyningssammenheng.

Det har i den senere tid vært gjort klart at det eksisterer uforsvarlig nedgravd spesialavfall både ved flere større industribedrifter og kommunale avfallsfyllinger i Norge.

Hydrogeologiske problemstillinger er fundamentale, og en har nå en massiv forskningsmessig satsing for å belyse problemstillinger både fra Danmark - Lossepladsprosjektet - og i Sverige arbeider Statens Naturvårdsverk med igangsettelse av"Deponi -90". Også i andre land er det igangsatt aktiviteter på dette området, jfr. USA.

I de land hvor kartlegging og undersøkelse av deponier har kommet langt, er det avdekket at det er knyttet store kostnader til å klarlegge forurensningspotensialet til den enkelte lokalitet(jfr. USA-Superfunds).

Et grunnleggende element i slike undersøkelser er boring og prøvetaking hvor det foregår en kontinuerlig utvikling internasjonalt.

DELTAKERE

Et av formålene med studiereisen var å legge et grunnlag for samarbeidsprosjekter imellom ulike miljøer i Norge. Ulike deltakende miljøer var derfor invitert til studiereisen.

Deltakerne var:

Eilif Danielsen	NGU
Jan Johansen	SFT
Tidemann Klemetsrud	NGU
Bernt Malme	NGU
Hans Myhre	Brødr. Myhre A/S
Kjell Myhre	Brødr. Myhre A/S
Trygve Aasland	C. H. Knudsen A/S

PROGRAM

Programmet var lagt opp slik at ulike miljøer, institusjoner og forvaltningsmyndigheter ble besøkt.

Tirsdag	30. mai	FN, New York
Torsdag	1. juni	Wash-Group, Washington DC
		EPA, Washington DC
Fredag	2. juni	Ingersoll Rand, Roanoke
Mandag	5. juni	DEQ i Oregon, Portland
Tirsdag	6. juni	CH^2M-Hill, Portland
Onsdag	7. juni	CH^2M-Hill, Portland
Torsdag	8. juni	DEQ, Oregon
Fredag	9. juni	CH^2M-Hill

Deltakerne deltok f.o.m. fredag 2. juni t.o.m. torsdag 8. juni.
Bernt Malme besøkte de andre institusjonene.

BRØNNBORING I U-LAND

FN-UNDP

FN har en bred aktivitet innen vannforsyning , også helt ned til å være oppdragsgiver for brønnboring i mange U-land.
Besøk hos UNICEF var det ikke mulig å få koordinert. UNDP v/Masha Brewster var kontaktperson.

UNDP er sentral i koordineringen av "International Drinking Water Supply and Sanitation Decade (1980-1990) (IDWSSD). Ref. vedlegg 1 og 2 som viser oversikt over dekningsgrad av sikker vannforsyning 1980-83 samt framdrift i 1985 .

UNDP koordinerer bl.a. arbeidet med teknisk samordning og samarbeide samt arbeid med retningslinjer innen bl.a. forvaltning av grunnvann.

Wash-Group

Wash-Group er en rådgivende gruppe som består av 8 hydrogeologer og som er finansiert av US-AID. US-AID benytter i stor grad Wash-Group ved vannforsyningsoppgaver i U-land. Omsetningen var på ca. 2-2,5 mill.$ i året.
Gruppen arbeider med problemstillinger fra lokaltilpasset problemløsning til generelle retningslinjer for bruk og beskyttelse av grunnvann vedlegg 3.
Kontaktperson var Philip Roark.

Det var selv etter stor innsats på vannforsyningssiden i Afrika stort behov for tjenester deriblant brønnboring. Strategien vedr. boreutstyr var entydig. Valg av boreutstyr som besto av enkel teknologi. Utstyret burde kunne vedlikeholdes lokalt og drives med lokale krefter. Videre burde det være lett og mobilt.

Etter en nærmere beskrivelse av NEMEK-modellen var fagpersoner i Wash-Group overbevist om utstyrskonseptets egnethet m.h.t. mobilitet, driftssikkerhet og hurtighet totalt i boreoperasjoner, montering - demontering.

En burde vurdere nærmere en internasjonalisering av utstyrskonseptet.

BORETEKNOLOGI

Ingersoll-Rand

Det ble gitt en omvisning på bedriften Ingersoll-Rand i Roanoke med vekt på konstruksjon og produksjon av senkborhammere. Videre demonstrasjon av testing av borhammere og borerigger. En nærmere diskusjon avklarte at Odex-boring med senkborhammer var lite benyttet i USA og at en var overrasket fra IR over at det "norske" konseptet med NEMEK-rigger, Odex og senkborhammere var så mobilt, fleksibelt samt at krav til tid for oppmontering, demontering var så lite. Boreriggene som IR produserte var mindre hensiktsmessige og moderne i forhold til hva en er vant med fra Norge.

Etter en helhetlig vurdering var den praksis en hadde lagt seg på i Norge hensiktsmessig både m.h.t.

- fleksibilitet
- mobilitet
- tidsforbruk
- driftskostnader

Br. Myhre redegjorde for deres teknikk på gjennomhullsboring som var ukjent for utviklingspersonellet i Ingersoll-Rand.

Ingersoll-Rand var interessert i en videre kontakt og oppfølging mot Br. Myhre både med utgangspunkt i teknikk ved gjennomhullsboring, men også for å se mindre utstyrsenheter Br. Myhre hadde utviklet.

IR hadde også under utvikling en Reverce Circulation-hammer med dual pipe system. Dette konseptet har tidligere vært benyttet ved mineralleting, men er overførbart på forurensningsundersøkelser for å unngå kontamineringsproblematikken.

Inntrykket av utstyr, boreoperasjoner, ble forsterket gjennom besøk på lokaliteter hvor boringer ble gjennomført i forbindelse med forurensningsundersøkelser.

Med det "norske konseptet" ville total boretidsforbruk (opprigging, demontering inkludert) være ca. 1/3 av hva som er vanlig i de tilfellene vi ble orientert om og som skulle være representativt for større deler av borefirmaene på USA's vestkyst.

Et annet og vesentlig forhold var også at boremannskapene vanligvis ikke hadde noen kompetanse innen geologi, hydraulikk, mens en i Norge vanligvis benytter bedre kvalifisert personell.

Prøvetakingsutstyr, jordprøver, som ble demonstrert var av ulik kvalitet m.h.t. å unngå kontamineringsproblematikken, jfr. vedlegg. Det var tydelig en viss usikkerhet m.h.t. anvendbarheten av de typene som vanligvis ble brukt. Interessen var stor for bedre prøvetakere, og spesielt systemer som utelukker kontamineringsproblematikken i forurensningsundersøkelser.

Utviklingsoppgaver innen dette feltet er åpenbare, samt at markedspotensiale er voksende både i USA og Europa.

EPA-SUPERFUND

I 1980 ble det vedtatt en lov om: "Comprehensive Environmental Response, Conpensation and Liability Act (CERCLA eller Superfund). Superfund avsetter en stor sum penger for hver 5-årsperiode som gir EPA mulighet til å foreta kortsiktige (removal) eller langsiktige (remedial) tiltak samt juridisk å bringe ansvarlige parter til finansieringen av disse. Utover CERCLA er EPA ansvarlig for forvaltningen av 8 andre lover som:

- Clean Air Act (CAA)
- Clean Water Act (CWA)
- Safe Drinking Water Act (SDWA)
- Resource Conservation and Recovery Act (RCRA)
- Toxic Substances Control Act (TSCA)
- Marine Protection, Research and Sanctuaries Act (MPRSA)
- Uranium Mill Tailings Radiation Control Act (UMTRCA)

Beskrivelse av Superfund

Superfund gir EPA rett til å overta ansvaret for lokaliteter og situasjoner som utgjør en fare for helse og miljø. EPA har gjenomført en kartlegging som oppdateres og hadde i 1987 registrert 25 000 avfallsplasser som potensielt hadde behov for innsats under Superfund.

EPA har hjemmel til etter Superfund å foreta kortsiktige (removal) eller langsiktige tiltak på en lokalitet avhengig av den aktuelle situasjonen.

Removal actions er kortsiktige tiltak for å få en situasjon under kontroll eller for raskt å renovere en lokalitet som utgjør en fare for helse og miljø.

Remedial actions er et langsiktig tiltaksprogram rettet mot forurensede deponier, lokaliteter med miljøfarlig avfall.

NPL lokaliteter identifiseres gjennom rapporteringer og inspeksjoner som EPA gjør på alle kjente deponeringssteder i USA, samt etter tips fra publikum.

Når en potensiell lokalitet identifiseres, gjenomfører EPA eller delstatsmyndigheter en foreløpig bedømmelse gjennom å studere tilgjengelig materiale for lokaliteten. Deretter gjøres en plassinspeksjon for å samle ytterligere informasjon. Med grunnlag i de fakta som foreligger sammenligner EPA lokalitetens forurensningsrisiko med andre plasser i USA. De lokaliteter som er mest graverende kommer på EPAs NPL-liste. For lokalitetene på NPL-listen blir det gjennomført en mer inngående undersøkelse av området, en såkalt "Remedial Investigation and Feasibility Study" (RI/FS) som skal bedømme egnede metoder for å renovere lokaliteten. Denne undersøkelsen omfatter en detaljert og omfattende prøvetaking og informasjonsinnsamling for å bedømme forurensningens karakter og utbredelse.

Gjennomføring og metodevalg for remedial actions gjøres av EPA i samarbeid med US Army Corps of Engineers. Alternativt kan i en del tilfeller delstatene selv gjennomføre remedial actions.

Ved utforming av remedial actions er EPA pålagt å velge kostnadseffektive remedial actions som i størst mulig grad skal være <u>permanente</u> løsninger.

Gjennomføringen skal skje innen visse tidsfrister. Alle NPL-lokaliteter skal ha en oversikt over det miljøfarlige avfallet som er deponert, resultater fra toxikologiske undersøkelser, resultater fra forskning i tilknytning til de forskjellige stoffene samt en bedømmelse av helserisiko for lokaliteten.

Feltbefaring - Superfund Sites

En ble vist 3 ulike lokaliteter:

1. Dalles, Oregon
   Impregneringsverksted for jernbanesviller.

   Problemstillingen var kreosotforurensning av jord og grunnvann samt boreteknologi.

2. Arlington, Oregon
   Sentrale mottaksanlegg for spesialavfall for Washington og Oregon.

   Problemstillingen var overvåking, prøvetaking.

3. Corvalis, Oregon
   Galvanoteknisk bedrift (krom).

   Problemstillingen var hvordan en hadde fullført opprensking og etablert renseteknologi på stedet.

Det vil bli for omfattende å beskrive i detalj de enkelte problemstillingene fra hver enkelt lokalitet.

Dalles

Lengre tids utslipp av kreosot fra fabrikken til Pasific Railways var i ferd med å true grunnvannsforsyningen til tettstedet Dalles.

Kreosot hadde infiltrert ned i underliggende permeable basalter som også var det sentrale grunnvannssmagasinet for byen. CH_2 M-Hill (konsulent) var i ferd med å etablere observasjons- og prøvetakingsbrønner i feltet.

Vedrørende selve boreteknologien var den delvis bestemt av de dimensjoner på observasjonsbrønner og retningslinjer for selve boroperasjonen som EPA hadde fastlagt. Utover dette var inntrykket at en benyttet grovt, overdimensjonert utstyr, air-rotary og tophammer. Utover dette en stor utstyrspark med mobilt verksted. Denne praksis medførte at boreoperasjonene tok lang tid og var dyre.

Arlington

Det var etablert ett sentralt mottaksanlegg for spesialavfall som mottok avfall fra Oregon og Washington. Dette var lokalisert i et øde semiarid område av Oregon jfr. vedlegg.

Avfallsbehandling i noe større grad forekom ikke. Deponering av tønner med noenlunde likt innhold ble konsentrert i separate deponier. Videre ble en del spesialavfall i væskeform stabilisert med finstoff av ukjent karakter før endelig deponering. Store mengder spesialavfall i væskeform ble tømt i store bassenger for fordamping. Stedet var allerede registrert som et superfund-site.

Med hensyn til konstruksjon av observasjonsbrønner; jfr. vedlegg.
Prøvetaking foregikk etter fastsatt program og en benyttet Well wizard (bladderpumpe) samt Hydrostar. Transportrørene for prøvetakingspumpene var av polyetylen og dekket med teflon på innsiden. En tok ut minimum 3 x brønnvannet før prøvetaking, samt at ledningsevnen måtte være konstant da prøven ble tatt.
Stor vekt ble lagt på at en skulle unngå krysskontaminering ved etablering av observasjons - overvåkingsbrønner.

Det generelle inntrykket fra hele dette sentrale mottaksanlegget var at en var i ferd med å skape et enormt forurensningsproblem lokalt og at deponiene, selv om det var benyttet lining, ikke var sikre, bl.a. på grunn av praksisen med å deponere tønner med avfall hvor en bare tok stikkprøver for å kontrollere innholdet, slik at en ikke kunne utelukke sammenblanding av ulike komponenter som ville kunne ødelegge liningen og infiltreres i underliggende avsetning.

Corvalis

En galvanoteknisk bedrift (krom) hadde hatt utette lagringskar og ukontrollert tømming av tungmetallslam og kromholdig væske. Dette var i nærheten av byens drikkevannsbrønner som lå i samme grunnvannsmagasin. Det ble vedtatt å fjerne bygningsmasse, fjerne forurenset jord og rense grunnvann.

Grunnvannsmagasinet var todelt med et øvre åpent magasin, et semipermeabelt lag og et nedre grunnvannsmagasin. Noe forurensing var observert i nedre magasin og en mistenkte at selve boreoperasjonen ved nedsetting av ca. 16 brønner hadde medført en kortslutning fra øvre til nedre magasin. Kommunen hadde gått til rettsak mot konsulentfirmaet som hadde hatt ansvaret for boringene for å få de til å betale opprenskningskostnadene denne forurensningen representerte.

Bygningsmassen ble vasket ned før riving p.g.a. svært kromholdig støv overalt i bygningen. Bygningsmassen utgjorde 1000 tonn avfall mens 1100 tonn jord ble gravd vekk og transportert til Arlington (deponeringskostnad pr. tonn ved Arlington var 300 $ pr. tonn. Videre ble det etablert et konvensjonelt fysikalsk/kjemisk renseanlegg hvor utpumpet forurenset grunnvann ble renset før det ble reinfiltrert. Det var etablert 23 ekstraksjonsbrønner/infiltrasjonsbrønner.

Kostnadene til de enkelte fasene var:

- Forundersøkelsen:	250 000 $
- Design av behandlingsanlegg og tiltaksløsning:	250 000 $
- Nedriving av bygningsmasse, etablering av vannbehandlingsanlegg m/ brønner og borttransport av forurenset jord:	2 000 000 $
- Drift og vedlikehold pr. år	180 000 $

Det var beregnet et behov for drift og vedlikehold i 10 år.

Konklusjon

En fikk et generelt inntrykk av at det investeres enorme beløp i opprydding og tiltak. Design av undersøkelsesprogrammene varierte noe både med de krav EPA, DEQ stilte fra sted til sted samt av den hydrogeologiske kompetanse de utøvende firmaer hadde. Erfarne hydrogeologer etablerte f.eks. mer effektive prøvetakings- og overvåkingsnett enn mer uerfarne som benyttet svært mange boringer for å avgrense problemet.

Videre hadde en hele tiden problemet med "How clean is clean", og hvor en i Oregon hadde etablert naturlige stedlige bakgrunnsverdier som referanseveredi. ("Cleaner is better, background is best"). Gjennom diskusjoner og befaring fikk en inntrykk av at en benyttet boreutstyr som var mindre mobilt, brukte lengre tid til både boreoperasjoner og opp- og nedmontering enn tilsvarende norsk utstyr basert på Odex-boremaskiner. Det prøvetakingsutstyret for jordprøver som ble benyttet var av enkel konstruksjon og spesielt "splitbarrel sampler" (vedl.) ble mye benyttet, men også "tube sampler". Markedet for slike prøvetakere var vanskelig å få oversikt over, men et inntrykk var at det eksisterer bedre prøvetakere utviklet i Skandinavia.

DEPARTMENT OF ENVIRONMENTAL QUALITY; (DEQ), OREGON

DEQ er delt opp i

1. Air division
2. Water division
3. Hazardous waste
4. Laboratory
5. Management
6. Regional operation
7. Environmental Clean-up.

DEQs budsjett er på ca. 20 mill $ årlig.

DEQ har etablert flere programmer som berører Hazardous waste.

Kartlegging og tiltak

DEQ hadde ved hjelp av 4 personer i løpet av 9 måneder fra mars 1988 gjennomført en kartlegging av utslipp av spesialavfall og eller lokaliteter med fare for slike utslipp. På grunn av stort tidspress benyttet en som kildemateriale egne arkiver og en informasjonskampanje. Lokalitetene ble inndelt i to grupper etter om det var et

- bekreftet utslipp, eller
- ubekreftet utslipp.

For å være et bekreftet utslipp måtte følgende skriftlig materiale foreligge:

1) Observert utslipp av en observatør fra EPA, DEQ eller annet offentlig organ.

2) Analysetester fra prøvetaking på stedet.

3) Tilståelse av eier eller operatør av lokaliteten at et utslipp hadde skjedd.

Var stedet registrert med et bekreftet utslipp, ble det lagt inn i en deponi-database (dbase III+) som en bekreftet lokalitet. De lokalitetene som ikke var bekreftet ble også lagret i databasen, men i en gruppe for videre under-søkelser. Eieren av lokaliteten ble varslet om konklusjonen og ved årsskiftet 1989 var det anker på konklusjoner for 210 av de ialt 325 stedene. Dette medførte at hele oversikten ble lagt på is til en hadde fått en juridisk løsning på problemet.

Dette programmet var etablert ved siden av det federale SUPERFUND-programmet. "State-Programme" hadde som målsetting å registrere alle lokaliteter med spesialavfallsforurensning, mens SUPERFUND bare konsentrerte seg om de mest forurensede lokalitetene.

I Oregon ble det nå registrert ca. 2 - 3 nye lokaliteter pr. måned. Videre øvde publikum og banker et stort påtrykk for å få et "Clearance certificate", slik at eiendommene var uten heftelser med hensyn til forurensning.

Med hensyn til finansiering av det statlige programmet hadde en tre kilder:

1. Avgift på firmaer som benyttet spesialavfall
2. Avgift på leverandører av petroleumsprodukter
3. Avgift på spesialavfall som deponeres.

En hadde behov for ca. 100 mill $ over de neste 6 år hvor industrien finansierte 75% og state government 25%.

Tiltaksarbeidet er delt opp i 4 faser (vedlegg). Første fase består i en foreløpig vurdering (preliminary assesment) hvor en benytter ca. 80 timer pr. lokalitet på en risikoanalyse. En framskaffer informasjon om driften av evt. bedrift, hvilke giftige materialer som ble benyttet og hvordan dette ble håndtert. Navn på eiere og operatører samt annen relevant informasjon samles inn. Denne informasjonen benyttes i et rangeringssystem hvor eksponeringsfare for mennesker og miljø tillegges stor vekt.

Underground tank programme

I alt 22 500 nedgravde tanker på 8 000 lokaliteter var registrert; ca. 3/4 er oljetanker. En hadde registrert at 90% av tankene hadde hatt utslipp.

På ca. 40-50% av lokalitetene var problemstillingen kun forurensning av jord, mens det på resten var langt mer komplisert med grunnvannsforurensning. En konkluderte med at enhver tank eldre enn 15 år hadde 75% sjanse for lekkasje.

Hazardous waste redution programme

DEQ har etablert et program for å redusere bruken og produksjonen av spesialavfall.

En har som målsettinger å:

- redusere bruken av giftige materialer,

- redusere bruken av giftige materialer,
- minimere avfallsmengden ved resirkulering og mindre forbruk av eks. unødvendig emballasje.

Bedriftene blir bedt om å vurdere sine "avfallsstrømmer" for om mulig å redusere mengdene.

DEQ gav teknisk assistanse og veiledning til mindre firmaer.

KONKLUSJON/ANBEFALING

Studiereisens hensikt var primært å se på brønnboringsteknologi, men også kartlegging, opprensking av forurenset grunn.

Det generelle inntrykket etter studiereisen er at det konseptet en arbeider etter i Norge er et konkurransedyktig produkt sammenlignet med praksis i USA. Dette bør kunne utvikles videre, spesielt innenfor forurensningsrelaterte problemstillinger hvor nøyaktighet, tid og pris er av stor betydning. For markedet innen vannforsyning - borebrønner i utviklingsland er det store muligheter p.g.a. mobilitet, enkelt utstyr med stor driftssikkerhet. Hele konseptet kunne også her selges f.eks. til UNDP som er oppdragsgiver for et stort antall brønnboringer i spesielt Afrika.

Det bør etableres kontakt og samarbeidsprosjekter mellom produsent, brønnborer og hydrogeologisk kompetanse for en videre utvikling og tilrettelegging av hele "produktet". Også norsk metodikk på gjennomhullsboring er langt framme sammenlignet med det vi ble presentert i USA.

Innenfor overordnet kartlegging av deponier og forurenset grunn er en ajour med deler av USA. Det nivå og omfang en har valgt i Norge på kartleggingen samsvarer med det nivået en nå velger å legge seg på i USA.

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Vedlegg

Vedlegg 1

The Water and Sanitation Decade Progress and Challenge

Since the United Nations General Assembly launched the "International Drinking Water Supply and Sanitation Decade" (IDWSSD) in 1980, substantial progress has been made in providing new water supply and sanitation services to people in both rural and urban areas of the developing world:

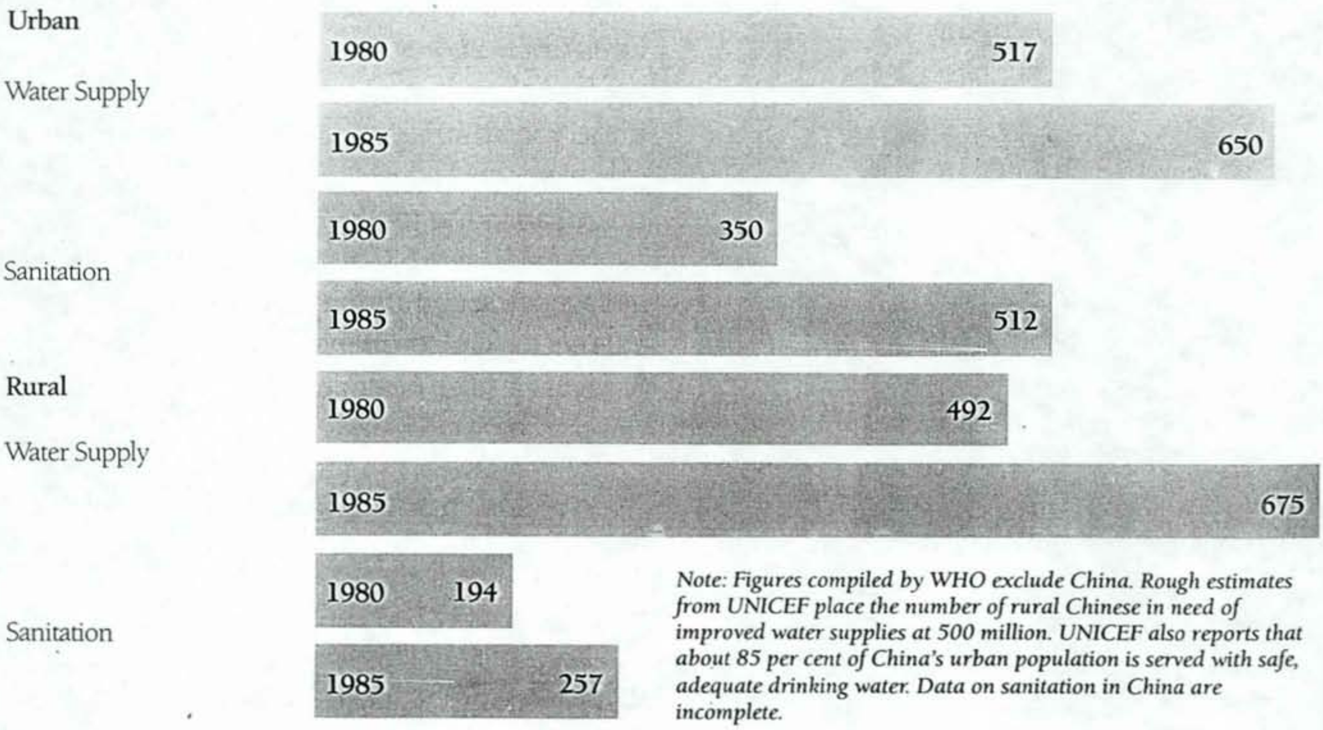
- Every day since the launch of the Decade, an average of 200,000 people gained access to safe water supplies, and 100,000 gained access to proper sanitation facilities.
- New or improved water supplies have been provided to over 500 million people throughout the developing world. Better sanitation has been provided to 250 million. The pace of construction of new water supply facilities was up three-fold during the first five years of the Decade.

The chart below illustrates the expanded service coverage achieved during the first half of the IDWSSD in the developing world.

Global Coverage *(in millions)*
All developing countries except China

1980 Population: 2,189
1985 Population: 2,474

(Source: IDWSSD Mid-Decade Progress Review, WHO, A39/11)



Note: Figures compiled by WHO exclude China. Rough estimates from UNICEF place the number of rural Chinese in need of improved water supplies at 500 million. UNICEF also reports that about 85 per cent of China's urban population is served with safe, adequate drinking water. Data on sanitation in China are incomplete.

Vedlegg 2

WATER DECADE REVIEW

Reported changes in water supply and sanitation 1980-83

Water supply (1980/1983) — Sanitation (1980/1983)

Coverage in figures (%)

Country		Water supply	Sanitation	Country
American Samoa	U	100	100	American Samoa
	R	100	92	
	U	100	100	
	R	64	100	
Angola	U	85	40	Angola
	R	10	15	
	U	90	29	
	R	12	15	
Argentina	U	65	89	Argentina
	R	17	32	
	U	72	94	
	R	17	32	
Bahamas	U	100	100	Bahamas
	R	n/a —	100 n/a	
	U	96	96	
	R	n/a —	— n/a	
Bangladesh	U	26	1	Bangladesh
	R	40	21	
	U	29	2	
	R	43	21	
Barbados	U	100	— n/a	Barbados
	R	n/a —	— n/a	
	U	100	— n/a	
	R	18	— n/a	
Bhutan	U	50	— n/a	Bhutan
	R	5	— n/a	
	U	n/a —	— n/a	
	R	14	— n/a	
Bolivia	U	69	37	Bolivia
	R	10	4	
	U	78	40	
	R	12	9	
Brazil	U	83	30	Brazil
	R	51	— n/a	
	U	86	33	
	R	53	— n/a	
Brunei	U	100	— n/a	Brunei
	R	95	— n/a	
	U	100	75	
	R	95	98	
Burma	U	38	15	Burma
	R	15	38	
	U	36	15	
	R	21	— n/a	
Burundi	U	90	40	Burundi
	R	20	35	
	U	90	50	
	R	22	52	
Cape Verde	U	100	34	Cape Verde
	R	21	10	
	U	99	49	
	R	27	8	
Cayman Islands	U	100	94	Cayman Islands
	R	n/a —	— n/a	
	U	85	— n/a	
	R	n/a —	— n/a	
Chile	U	100	99	Chile
	R	17	— n/a	
	U	100	100	
	R	18	4	
Colombia	U	100	100	Colombia
	R	79	4	
	U	n/a —	96	
	R	n/a —	13	
Congo	U	36	17	Congo
	R	3	0	
	U	42	— n/a	
	R	7	— n/a	
Cook Islands	U	100	100	Cook Islands
	R	n/a —	76	
	U	100	100	
	R	85	100	
Costa Rica	U	100	93	Costa Rica
	R	68	82	
	U	99	100	
	R	99	— n/a	

Country		Water supply (1980/1983) Coverage in figures (%)	Sanitation (1980/1983) Coverage in figures (%)	Country
Cyprus	U	100	100	Cyprus
	R	100	100	
	U	100	100	
	R	100	100	
Yemen (Democratic)	U	85	70	Yemen (Democratic)
	R	25	15	
	U	73	69	
	R	39	33	
Djibouti	U	50	43	Djibouti
	R	20	20	
	U	80	75	
	R	40	18	
Dominican Republic	U	85	25	Dominican Republic
	R	33	4	
	U	85	41	
	R	32	9	
Ecuador	U	82	39	Ecuador
	R	16	14	
	U	98	64	
	R	21	26	
El Salvador	U	67	80	El Salvador
	R	40	26	
	U	— n/a	— n/a	
	R	42	34	
Fiji	U	94	85	Fiji
	R	66	60	
	U	100	— n/a	
	R	48	— n/a	
Guam	U	100	— n/a	Guam
	R	100	100	
	U	100	100	
	R	100	100	
Guatemala	U	89	45	Guatemala
	R	18	20	
	U	90	48	
	R	26	28	
Guinea-Bissau	U	18	21	Guinea-Bissau
	R	8	13	
	U	21	6	
	R	37	18	
Guyana	U	100	100	Guyana
	R	60	80	
	U	100	100	
	R	60	80	
Haiti	U	48	39	Haiti
	R	— n/a	10	
	U	58	41	
	R	25	12	
Honduras	U	50	49	Honduras
	R	40	26	
	U	91	50	
	R	55	40	
Hong Kong	U	100	100	Hong Kong
	R	95	— n/a	
	U	100	— n/a	
	R	93	— n/a	
India	U	77	1	India
	R	31	27	
	U	80	1	
	R	47	30	
Indonesia	U	35	21	Indonesia
	R	19	29	
	U	40	30	
	R	29	31	
Lao (PDR)	U	21	— n/a	Lao (PDR)
	R	12	3	
	U	28	13	
	R	20	4	
Liberia	U	— n/a	18	Liberia
	R	16	5	
	U	71	24	
	R	20	20	
Madagascar	U	80	9	Madagascar
	R	7	— n/a	
	U	73	3	
	R	9	— n/a	
Malawi	U	77	100	Malawi
	R	37	81	
	U	66	75	
	R	49	— n/a	

Water supply (1980/1983) — Sanitation (1980/1983)

Coverage in figures (%)

Country		Water supply (0 10 20 30 40 50 60 70 80 90)	Sanitation (90 80 70 60 50 40 30 20 10 0)	Country
Malaysia	U	90	100	Malaysia
	R	49	55	
	U	97	100	
	R	71	59	
Maldives	U	n/a —	1	Maldives
	R	3	60	
	U	n/a —	1	
	R	7	71	
Mauritania	U	80	5	Mauritania
	R	85	— n/a	
	U	80	4	
	R	n/a —	0	
Mexico	U	64	51	Mexico
	R	43	12	
	U	91	78	
	R	40	12	
Nepal	U	83	1	Nepal
	R	7	16	
	U	71	1	
	R	11	16	
Nicaragua	U	91	35	Nicaragua
	R	10	— n/a	
	U	91	— n/a	
	R	n/a —	— n/a	
Niger	U	41	36	Niger
	R	32	3	
	U	41	36	
	R	33	3	
Nigeria	U	60	— n/a	Nigeria
	R	30	— n/a	
	U	60	— n/a	
	R	30	— n/a	
Pakistan	U	72	42	Pakistan
	R	20	2	
	U	78	53	
	R	24	6	
Panama	U	100	62	Panama
	R	65	28	
	U	97	61	
	R	26	— n/a	
Papua New Guinea	U	55	96	Papua New Guinea
	R	10	3	
	U	55	91	
	R	10	3	
Paraguay	U	39	95	Paraguay
	R	10	29	
	U	46	92	
	R	10	84	
Peru	U	68	57	Peru
	R	21	0	
	U	73	57	
	R	18	0	
Philippines	U	65	81	Philippines
	R	43	67	
	U	53	75	
	R	55	47	
Republic of Korea	U	86	100	Republic of Korea
	R	61	100	
	U	n/a —	— n/a	
	R	60	— n/a	
Rwanda	U	48	60	Rwanda
	R	55	50	
	U	55	60	
	R	60	60	
Samoa	U	97	86	Samoa
	R	94	83	
	U	95	32	
	R	94	86	
Saudi Arabia	U	92	87	Saudi Arabia
	R	87	50	
	U	100	100	
	R	68	33	
Senegal	U	77	100	Senegal
	R	25	2	
	U	63	87	
	R	27	— n/a	
Sierra Leone	U	50	31	Sierra Leone
	R	2	6	
	U	61	46	
	R	6	10	

Water supply (1980/1983) — Sanitation (1980/1983)

Coverage in figures (%)

Country		Water supply (1980/1983)	Sanitation (1980/1983)	Country
Singapore	U	100	80	Singapore
	R	— (n/a)	— (n/a)	
	U	100	100	
	R	— (n/a)	— (n/a)	
Solomon Islands	U	91	82	Solomon Islands
	R	20	10	
	U	96	80	
	R	45	21	
Somalia	U	60	45	Somalia
	R	20	5	
	U	65	48	
	R	21	5	
Sri Lanka	U	65	80	Sri Lanka
	R	18	63	
	U	76	— (n/a)	
	R	26	— (n/a)	
Sudan	U	100	63	Sudan
	R	31	— (n/a)	
	U	100	73	
	R	—	— (n/a)	
Suriname	U	100	100	Suriname
	R	— (n/a)	79	
	U	100	100	
	R	100	100	
Thailand	U	65	64	Thailand
	R	63	41	
	U	50	50	
	R	70	44	
Togo	U	70	24	Togo
	R	31	10	
	U	68	34	
	R	26	8	
Tokelau	U	— (n/a)	— (n/a)	Tokelau
	R	100	19	
	U	— (n/a)	— (n/a)	
	R	100	50	
Tonga	U	86	97	Tonga
	R	70	94	
	U	91	100	
	R	90	97	
Trinidad & Tobago	U	100	95	Trinidad & Tobago
	R	93	88	
	U	100	100	
	R	96	96	
TTOP	U	25	75	TTOP
	R	23	4	
	U	68	79	
	R	24	7	
Tunisia	U	100	100	Tunisia
	R	17	— (n/a)	
	U	100	— (n/a)	
	R	— (n/a)	— (n/a)	
Uganda	U	45	40	Uganda
	R	8	10	
	U	45	— (n/a)	
	R	12	10	
Uruguay	U	96	59	Uruguay
	R	2	60	
	U	95	— (n/a)	
	R	3	— (n/a)	
Vanuatu	U	65	95	Vanuatu
	R	53	68	
	U	— (n/a)	86	
	R	50	64	
Venezuela	U	91	90	Venezelua
	R	50	70	
	U	— (n/a)	— (n/a)	
	R	65	2	
Viet Nam	U	— (n/a)	— (n/a)	Viet Nam
	R	32	55	
	U	— (n/a)	— (n/a)	
	R	31	70	
Yemen	U	100	60	Yemen
	R	60	18	
	U	100	75	
	R	75	21	
Zambia	U	65	100	Zambia
	R	32	48	
	U	65	100	
	R	33	48	

Vedlegg 3.

1. THE WASH EXPERIENCE

Background

The Water and Sanitation for Health Project (WASH) was created to amplify the efforts of the United States government to assist developing countries to meet the goals of the United Nations International Drinking Water Supply and Sanitation Decade (1981-1990). The Decade was conceptualized at a U.N. Water Conference at Mar del Plata, Argentina, in 1977. The action plan developed at this conference called on all countries to vigorously address the water and sanitation needs of over two billion people on Earth. The goal of the Decade is safe drinking water and sanitation for all by 1990.

Now completing its seventh year, the WASH Project has built up a significant body of knowledge and experience about what makes for success in water supply and sanitation projects. This accumulation of knowledge and experience is the end product of WASH's work in fifty countries on 360-plus activities, most of them in response to requests for assistance from the overseas missions of the United States Agency for International Development.

As part of its activities WASH has produced a large number of field and technical reports: field reports describe how a specific water and sanitation problem was dealt with by WASH consultants working overseas; technical reports describe research carried out by WASH and/or contain stand-alone generic guidelines that can be used in many countries and under diverse circumstances to solve various water- and sanitation-related problems.

This progress report presents summaries of the activities carried out by WASH to date and lists all of WASH's technical and field reports. To make it easy for others to access this body of material, WASH has organized it by category. WASH activities and reports are cross-referenced by geographical region, by country and by subject matter.

For this progress report, WASH would also like to emphasize certain activities that are relevant to current issues in the Water Decade. Accordingly the following sections of this text highlight WASH activities in the following areas.

- Decade Planning
- Institutional and Human Resources Development
- Finance and Cost Recovery
- Operations and Maintenance
- Community Participation and Hygiene Education
- Improving Programming in Water Supply and Sanitation

These categories closely parallel the "global concepts" discussed at a conference of bilateral, multilateral, and United Nations agency representatives who met in October 1987 in Interlaken, Switzerland, to take stock of the progress that has been made and constraints that still exist in meeting the goals of the Water Decade.

The categories that were discussed at the Interlaken Conference and that will be highlighted in the following sections all concern "software" problems; that is to say, they do not focus as much on the pumps and pipes and latrines as they do on human institutional problems: how can water and sanitation agencies be organized and managed for maximum effectiveness, how can water and sanitation workers be trained to take on new roles, how can a village group learn to maintain its handpump, or what is needed at the planning stages if water projects are to be sustainable? This emphasis on "software" does not mean, of course, that the hardware is not important or that WASH does not concern itself with solving hardware problems. Far from it—"hardware" and "software" issues cannot be divorced.

In the following pages, some illustrations are given of WASH "products" (technical and field reports) that fall into each category. Note that almost none of these products fits neatly into any one category because WASH uses an interdisciplinary approach in carrying out its assignments and because the categories clearly overlap.

Decade Planning

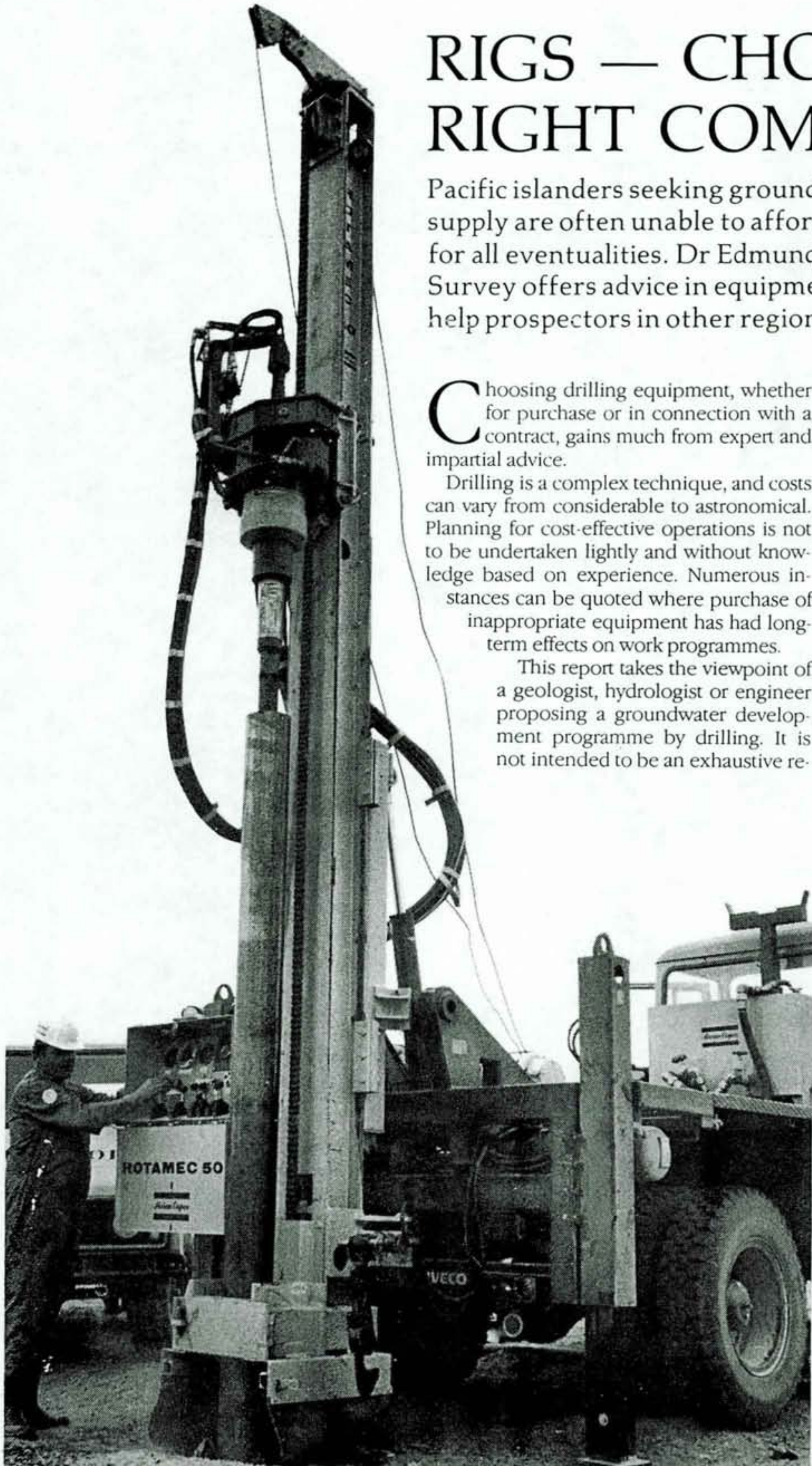
At the inception of the Water Decade, it was envisaged that developing countries would establish national water and sanitation coverage targets and prepare country-level Decade plans. By early 1981, only nine countries had developed plans. By 1983, this number had grown to 59 countries, with another 31 working on their plans. Through the WASH Project, A.I.D. has been actively helping countries in Africa (where Decade planning lagged) to develop their plans. To date, WASH has provided planning assistance to the Central African Republic, Zaire, and Swaziland and is currently collaborating with the World Health Organization to strengthen the national planning process in Djibouti.

WASH uses a highly collaborative approach to Decade planning whereby the pace of planning

Vedlegg 4

RIGS — CHOOSING THE RIGHT COMBINATION

Pacific islanders seeking groundwater sources for domestic supply are often unable to afford a range of drilling equipment for all eventualities. Dr Edmund Wright* of the British Geological Survey offers advice in equipment selection which could also help prospectors in other regions



An Atlas Copco Rotamec 50DH rotary drill rig drills wells in a UNDP financed programme in Bolivia.

Choosing drilling equipment, whether for purchase or in connection with a contract, gains much from expert and impartial advice.

Drilling is a complex technique, and costs can vary from considerable to astronomical. Planning for cost-effective operations is not to be undertaken lightly and without knowledge based on experience. Numerous instances can be quoted where purchase of inappropriate equipment has had long-term effects on work programmes.

This report takes the viewpoint of a geologist, hydrologist or engineer proposing a groundwater development programme by drilling. It is not intended to be an exhaustive review of drilling methods, concentrating instead on issues relating to a drilling programme in the Pacific region.

Selection of equipment must be preceded by decisions on the actual work programme Factors which bear on selection are:

- Depth to be drilled and geological formations to be encountered;
- Occurrence of aquifers in the drilled sequence;
- Borehole design including hole diameters and construction materials;
- Geographical location of drilling area, mainly in relation to position of base workshops and source of materials supply; also transport facilities;
- Terrain and local access;
- Numbers of holes to be drilled and target rate; and
- Availability of drilling crew, either trained or potential.

These factors will be looked at in more detail in the context of drilling in the Pacific region, but, to assist those with negligible background knowledge, a brief review of drilling procedures is necessary.

In drilling, rock formations must be broken or cut and the pieces (cuttings) must be brought to the surface. Rock is a term used loosely for any naturally occurring component of the earth's crust — whether consolidated or unconsolidated — massive, such as fresh granite, or plastic, such as clay.

Rock cutting is achieved in the main by one of three methods:

Percussive, which involves either the repeated lifting and dropping of a heavy tool (drill bit) on the end of a wire rope or less commonly by means of a device which impacts periodically on to a length (string) of rigid drill pipe.

Rotary, in which a cutting bit attached to drill pipe is rotated and simultaneously forced downwards under pressure. The action is

* *Dr E P Wright, British Geological Survey, Hydrogeological Adviser to the UK Overseas Development Administration. This article is published by permission of the Director of the BGS.*

effectively one of crushing and gouging. The pressure may be exerted by some form of mechanical 'pull down' to increase the loading on a bit or by coupling especially heavy lengths of drill pipe (drill collars) immediately above the bit. Both techniques are effectively limited by the dead weight of the rig. The drill bit may be a rock roller type with two or three rotating cones for hard rock or winged drag bits for clay or unconsolidated rocks such as sand or silts. Other variations of rotary drilling include auger drilling or coring with a core barrel. The rotating force or torque is a critical factor in the process.

Rotary-Percussive, which is comparable to rotary but associated with a percussive device to increase effectiveness. It is employed most effectively in hard rock and most particularly by means of a hammer operated by compressed air, located generally down the hole (DTH) or less effectively on the surface. The degree of impact is approximately proportionable to the air pressure.

Other methods employed for drilling are in the main very specialised and sophisticated techniques, such as the thermal drill. An exception is the water jet which may be used to make a hole through very soft and loose, relatively fine grained sediments.

Removal of the cuttings is also carried out in a variety of ways. The most important are:

Mechanical: bailing; the use of augers (bucket or continuous flight).

Circulation: by means of a fluid which carries the cuttings. The fluid may be compressed air, water, foam or drilling mud. Circulation is most commonly direct down the drill pipe and up the annulus, but, for special requirements (e.g. large diameter hole in unconsolidated sediments), direction of circulation may be reversed.

Coring: by means of a core barrel with an annular cutting bit (single/double tube); in soft material, a tube may be mechanically driven a short distance.

In accordance with these techniques, drill rigs may be referred to as cable-tool, rotary or air hammer. However, combination rigs are now frequently used although constraints of cost and design may limit some of the techniques.

Cable-tool percussion rigs may have a rotary attachment. The wire line and bit may operate over a beam or directly from a pulley. The latter method is more commonly employed on the larger rigs and appears to be more effective in keeping a hole straight.

Multipurpose air hammer-rotary rigs are employed for moderate depths and variable rock type. A considerable number of design variations exist such as top drive or kelly drive, hydraulic or mechanical feed, etc, and when added to all the ancillary equipment, mud pumps, compressors, mountings and transport, as well as the variations in drill tools, prospective buyers are presented with a somewhat bewildering range of possibilities.

For any one type of rig, size and weight are roughly proportional to cost and capacity, and selection of a particular rig will depend on other factors which may range from service facilities to personal experience. It would be unwise to select a rig which will be operating most of the time close to the limit of its capacity. The geological sequence at a site is rarely predictable in detail and it is well to have some extra power for emergency uses.

The problem of choice becomes greater when more than one technique may be employed. The situation most frequently arises where either cable tool percussion or rotary/hammer rigs may be used. The latter are high performance rigs which are costly and complex and the entire programme of operation has to be given consideration in order to ensure cost effective use.

Drilling in the Pacific region is mainly concerned with domestic water supply. The rock types most likely to be encountered include coral limestones and sandy limestones, volcanics (lavas and agglomeratic rocks), and alluvial sequences in some of the larger islands. The overburden is rarely of significant thickness and is mainly the soil profile.

A Dando-800 percussion rig with rotary attachment working in Kenya.

Volcanic Rocks

Some differentiation must be made between the western and eastern Pacific. In the latter region and apparent most markedly in the islands of Hawaii and French Polynesia, there occur thick aquifers containing highly permeable basaltic rocks. The high permeability relates mainly to vesicular layers and to jointing and fracturing in the lavas close to the margins of flows. The thickest saturated sequences which may attain several hundred metres are usually a consequence of containment by vertical dyke systems.

Abstraction is by both vertical and horizontal boreholes and a combination of deep drilling (up to 400m) and high yields has required drilling diameters of up to 8in (200mm). Flowing yields of some of the horizontal boreholes in French Polynesia attain 100 litres/s.

A combination of hard rock, deep drilling in both horizontal and vertical positions, and high permeability indicate that the most suitable rig would be a combined air hammer-rotary of medium to large size. The air hammer operation will give rapid penetration in the unsaturated zone or sequences of relatively low permeability; and the use of foam will extend the range of this technique. For the highly permeable sections, it becomes increasingly difficult for air circulation to cope with the fluid inflow, and conversion to rotary with rock roller bits may be required.

The sequences in the Western Pacific tend to be more complex, with volcanic formations, both flows and pyroclastics, alternating with volcano-sedimentary formations including reef and shelf deposits (argillite, marl and limestone). Permeabilities of the volcanic sequences tend to be low or moderate and on the whole, development of the groundwater in volcanic rocks in the Western Pacific is not advanced. Requirements will mainly be for domestic supply.

Drilling depths will depend on a combination of geological and economic factors, principally relating to the costs of alternative supply sources and the scale of the demand. For low yielding boreholes (<3 l/s) and in the context of domestic supply for rural communities, drilling depths are unlikely to exceed 150m and will probably be less than 100m. The boreholes are likely to be completed with open hole or in part with slotted casing and a diameter of 6-8in (150-200mm).

The choice of drilling rig would mainly lie between a cable-tool rig of medium weight and a light-medium air hammer-rotary. Air hammer technique might suffice for all production wells in volcanic rocks of low permeability, but combination rigs are not much more expensive and could also cater for high permeability aquifers or alluvial formations. The features, both advantages and disadvantages, are listed below for each type. The standard criteria assumed are diameters up to 8in and drilling depths to 150m.

Medium Weight Cable Tool Rig

Fairly cheap, about $40,000-50,000. Simple, reliable, easy to operate and maintain, but very slow in hard rock. Rig is fairly heavy and cumbersome to transport.

Air Hammer-Rotary

Expensive, about $80,000-105,000; essential equipment includes large compressor and mud pump. Fairly complex and therefore more difficult to operate and maintain. Drills very fast in hard rock. Relatively light and manoeuvrable, particularly when emphasis is on air hammer operations. Size and weight limitation constrained by rotary operation.

Limestone: Raised Reef or Shelf Limestones

Rocks of this group are medium-hard. Permeability is associated with fractures and fissures, and aquifers may be high yielding. Similar borehole design to that identified for the more typical volcanic rocks would be suitable, but with close attention to protection against pollution if the limestone occurs on outcrop.

The same rigs would operate, but cable tool percussion would have additional advantages in that the rock is not unduly hard, and the method avoids problems of lost circulation. Unless the latter problem constitutes a major constraint, final selection is likely to be influenced by other factors in the drilling programme, notably the number of holes to be drilled and the urgency.

Recent Coral Reef Sequence on Low Islands

The recent coral limestones are relatively soft but become harder when cemented, and the sequence may include calcareous sands and marls. The limestones are of variable permeability from low to high, but the aquifers are relatively thin, being constrained by the available static head, which can only be a few metres at most on low islands.

The fresh water of potable quality generally does not exceed 20 times the static head above sea level. The depth of boreholes is kept as low as possible in order to minimise the upward coning of saline water and typically may be less than 20m. Boreholes may be required for production or for exploration and monitoring purposes. Other techniques of groundwater development such as dugwells or galleries are often more efficient for freshwater lens situations.

Cable-tool rigs are likely to be adequate and convenient for most purposes. They avoid the problem of lost circulation and make it easier to interpret lithological and water quality changes during drilling. Core sampling is often desirable and this can be accomplished by a rotary attachment.

Alluvial Formations

Alluvial sequences occur on larger islands such as Efate in Vanuatu. They are soft and variably productive. Larger hole sizes than the production casing/screen may be needed in order to accommodate a gravel pack. Considerable care is needed to obtain the correct selection of screen openings and pack design and must take account of such factors as aquifer grain size variations, chemistry of water, proposed pumping rate, etc.

Most of the alluvial sequences occur at low elevations and hole depths are not likely to be great. Cable-tool rigs may be adequate and indeed are able to drill larger hole sizes more easily than an equivalent size of rotary rig. Problems can occur with running sands or boulder beds.

Other considerations

Other less technological issues will need to be taken into account. Most of the island countries of the Pacific region are not so well endowed that they can afford the purchase of a range of drilling equipment to meet all eventualities. Versatility may therefore be a major asset.

Perhaps the most important issue is ensuring that the equipment is the most cost effective and compatible with the future programmes and target objectives. Larger scale programmes and shorter time scales may allow stockpiling of materials, provision of field workshops and mechanical back-up including personnel, and the use of high performance equipment. Transportation costs, which can be a major factor, may thereby be reduced.

Cable-tool rigs have many advantages but they are slow and relatively cumbersome. Transportation of such rigs to widely dispersed islands to drill the occasional hole will not achieve much and the transportation costs will be a significant component of the total budget. The disadvantages will be enhanced if the rocks are very hard, such as volcanic lavas. On the other hand, penetration rates in softer recent reef limestones will be reasonably fast and for low limestone islands, this cheaper option in drilling equipment is likely to be more appropriate.

Combination rigs have been referred to earlier, the most typical being cable-tool rigs with rotary attachment and rotary-percussion (down the hole hammer). There is scope for further improvement of combination facilities, notably perhaps in better combinations of rotary and cable-tool (the typical rotary attachments to standard cable-tool seem of limited value) and of cable-tool with rotary-percussion. The advantages of cable-tool operations in lithological sampling, drilling lost circulation zones, some well development processes and general reliability in use would be significantly enhanced in combination with the faster rotary or rotary percussion facilities.

There are few technical problems in combining rotary and air hammer percussion. The hammer is substituted for the rotary drilling bit and air has to be the main flushing medium. More consideration is required for the addition of cable-tool — the need for a suitable winch for manipulating heavy weights (drill string) and ensuring adequate space on the platform for easy and efficient operation. An additional cost for a cable tool facility might be of the order of 5-10% above that of the basic rotary or rotary-DTH rig.

Visit of Geological Survey of Norway
June 5, 1989

9:15 - 9:30	Fred Hansen, Director, Oregon Department of Environmental Quality
9:35 - 10:10	Alan Solares and Sara Lauman, Environmental Cleanup Division -- Discussion of Legislative Issues
10:15 - 11:00	Marilyn Daniel, John Odisio, Mike Zollitsch, Environmental Cleanup Division -- Site Discovery
11:00 - 12:00	Mike Downs, Division Administrator; Mary Wall, Manager, Policy Section; Tom Miller, Manager, Site Response Section; Lon Revall, Manager, Underground Storage Tank Cleanup Section; Dave St. Louis, Manager, Site Assessment Section -- General Discussion
LUNCH	
1:15 --	Leave for tour of Boeing TCE Aeration Plant

NORWEGIAN GEOLOGICAL SURVEY
VISIT TO PDX

Tuesday, June 6, 1989

Itinerary

8:00 am	Meet at Portland Office
8:00 - 8:30 am	Rogue Room - Introduction to CH2M HILL
	Mike Kennedy, Jack Payne, Jeff Dresser Ken Shump, Nofal Kasrawi
8:45 am	Depart for The Dalles Jeff Dresser, Ken Shump
10:45 am	Arrive the The Dalles, UPRR
10:45 - 11:15 am	Briefing at UPRR
11:15 - 12:00 pm	Site Tour
12:00 - 12:30 pm	Lunch
12:30 pm	Leave for Arlington
2:00 pm	Arrive at Chemical Waste Management, Arlington
2:00 - 3:30 pm	Site tour
3:30 pm	Leave for Portland
6:30 pm	Arrive in Portland
7:30 pm	Cocktails at Atwater's (ADAMS Room)
8:00 pm	Dinner at Atwater's (ADAMS Room)
	Mike Kennedy, Jack Payne, Greg Peterson (?), Ron Topazio, Nofal Kasrawi, Jeff Dresser, Ken Shump, Christy Smith, Jay Mackie (?)
	Dinner selections: Salmon, Chicken, Sirloin

Facts About DEQ's Hazardous Substance Facility Inventory

The Department of Environmental Quality's Environmental Cleanup Division is responsible for investigating and cleaning up sites contaminated with hazardous substances throughout the state. In order to do this, DEQ must first identify all such sites. The Site Discovery Program relies on four sources of information: DEQ files, records and files from other state agencies that deal with hazardous substances, information about industries which use hazardous substances, and reports from individuals with knowledge of possible contamination.

What Happens When a Site is Identified?

Sites with a confirmed release of hazardous substances will be placed on an Inventory List that will be presented to the Governor, the Legislature and the Environmental Quality Commission. The list will also be available to the public. The first list will be ready in January 1989 and will be updated annually.

What is a Hazardous Substance?

A hazardous substance is any substance that, when released to the environment, may present substantial danger to public health, welfare or the environment. Hazardous substances can be liquids, solids or sludges and may be by-products of manufacturing or commercial products such as gasoline.

What is a Confirmed Release?

A release is any spilling, leaking, emitting or leaching into the environment. Facilities where there is a threat of release are also included on the Inventory. A release can be confirmed by:

- Laboratory data from an environmental sample, or
- Documented observation by a government inspector that a release from a known source has occurred or is a threat, or
- A written statement from the owner, operator or authorized representative of the facility that a release has occurred.

What's on the Inventory List?

The Inventory will include information, if known, about the facility's history, the hazardous substances present, the owners and operators of the site, when the release occurred, and potential or immediate threats.

How is the Owner of a Site Notified?

Thirty days before a facility is added to the Inventory, the DEQ Director will send the owners of the facility a certified letter saying that the site will be included on the Inventory.

Can the Owner Appeal the Listing?

The owner can appeal the decision to add a facility to the Inventory by writing to the DEQ Director within 15 calendar days after receiving the notification letter. The appeal will be conducted as a contested case hearing. If a hearing is requested, the decision to list the facility on the Inventory will be postponed until the appeal is resolved.

What Happens After Sites are Listed on the Inventory?

Sites on the Inventory will be scheduled for a preliminary assessment. The preliminary assessment will determine if cleanup, further investigation, or no further action is required.

What If the Owner is Already Working With DEQ?

The Environmental Cleanup Law requires DEQ to examine all sites in the state with confirmed releases of hazardous substance -- whether or not they've been addressed by another program in the past.

If a Site isn't on the Inventory Does That Mean it's Not Contaminated?

Not necessarily. Because the Inventory only lists sites with confirmed releases, not all contaminated sites will be listed. Also, a site does not have to be listed on the Inventory before the Department can require necessary action.

What Happens to Facilities on the Inventory?

That depends on the status of the site. Often the first step is to conduct a preliminary assessment to determine if further cleanup or investigation is needed. At some sites, investigations have already been done or cleanup action has taken place. The Department will schedule follow-up actions based on the environmental hazards posed by the contamination and the Department's resources.

Who will Pay for these Additional Investigations?

The law requires those responsible for causing the contamination to pay for site cleanups and investigations. The owners or operators of a listed facility who receive the listing notification letter are not necessarily responsible for the contamination or legally liable for the costs of cleaning it up. If those responsible are unable or unwilling to pay for the necessary work, the Department can do it and then recover the cost from those responsible for the contamination.

For more information about the Environmental Cleanup Law or the Inventory process, contact the Environmental Cleanup Division at 229-5733 or toll-free in Oregon at 1-800-452-4011. (11/88)

Facts About Environmental Cleanup Rules

"Cleaner is better, background is best," is the philosophy behind the Department of Environmental Quality's new Environmental Cleanup (superfund) rules. The rules address the level of cleanup required at sites contaminated with hazardous substances in Oregon. These sites range from large abandoned industrial areas with major groundwater contamination to small areas affected by leaks from underground storage tanks.

..."Background is the level of hazardous substances that were naturally present at the site before any or all past or present releases..."

The rules establish procedures for investigating potentially contaminated sites in order to determine whether hazardous substances have been released and the level of cleanup required. If a release has occurred, the site will be studied in more detail and, if necessary, a remedial action (cleanup method) will be selected.

Sites must be cleaned up to the background (pre-release) level of the hazardous substance. If cleanup to background is found to be unfeasible, the Director of DEQ must select an alternative remedial action that is both feasible and protective.

There are four major activities -- Preliminary Assessment, Remedial Investigation, Feasibility Study, and Remedial Action -- that must be performed by any person who is ordered or authorized by the DEQ director.

Preliminary Assessment (1)

The purpose of the Preliminary Assessment is to confirm whether hazardous substances have been released into the environment and whether further study or cleanup is needed. The Preliminary Assessment will generally include information such as the facility history, hazardous substances used and how they were managed, names of owners and operators, and potential or immediate threats to public health or the environment posed by the site. As a result of the assessment, a determination will be made if further action is needed.

Remedial Investigation (2)

If the Preliminary Assessment confirms that a site poses a threat to the public health or the environment a Remedial Investigation will be conducted. The purpose of a Remedial Investigation is to determine the full nature and extent of the contamination. It includes three major components:

- Characterization of the hazardous substances to determine what substances are present and their concentrations;
- Characterization of the soil, groundwater, surface water, and air at the site to determine the extent of the contamination; and,
- An Endangerment Assessment to evaluate potential or actual hazards to public health and the environment.

Feasibility Study (3)

The Feasibility Study develops different options for cleaning up the site based on information compiled during the Remedial Investigation. The different options will reach different levels of cleanup.

The Feasibility Study includes two major components: The development of remedial action options and an evaluation of these options. The options will identify a variety of cleanup levels ranging from Background Level, to the lowest concentration level that can be attained by the highest and best technology available, to the lowest concentration level that can be reached by available technology that is feasible.

In cases where cleanup technology is not feasible, other measures such as environmental hazard notices, which supplement, or substitute for, a cleanup may be necessary.

Selection of the Remedial Action (4)

All of the information gathered in the first three activities is used by the Director of DEQ to determine the cleanup level and select the remedial action for a particular site. The goal of the rules is to clean up sites to background or, if that is not feasible, to the lowest concentration level that:

- Protects present and future public health, safety, welfare and the environment; and
- To the maximum extent practicable is cost effective, implementable, effective and uses permanent solutions and alternative technologies or resource recovery technologies.

Background is the target that the Director uses to begin the remedial action selection. Background is the level of hazardous substances that were naturally present at the site before any or all past or present releases due to human activities.

However, if the technology to reach Background Level is not available or the remedial action is not feasible, then the concentration level may begin to rise above the background level. Thus, "cleaner is better, background is best," is the guiding principle behind remedial action selection.

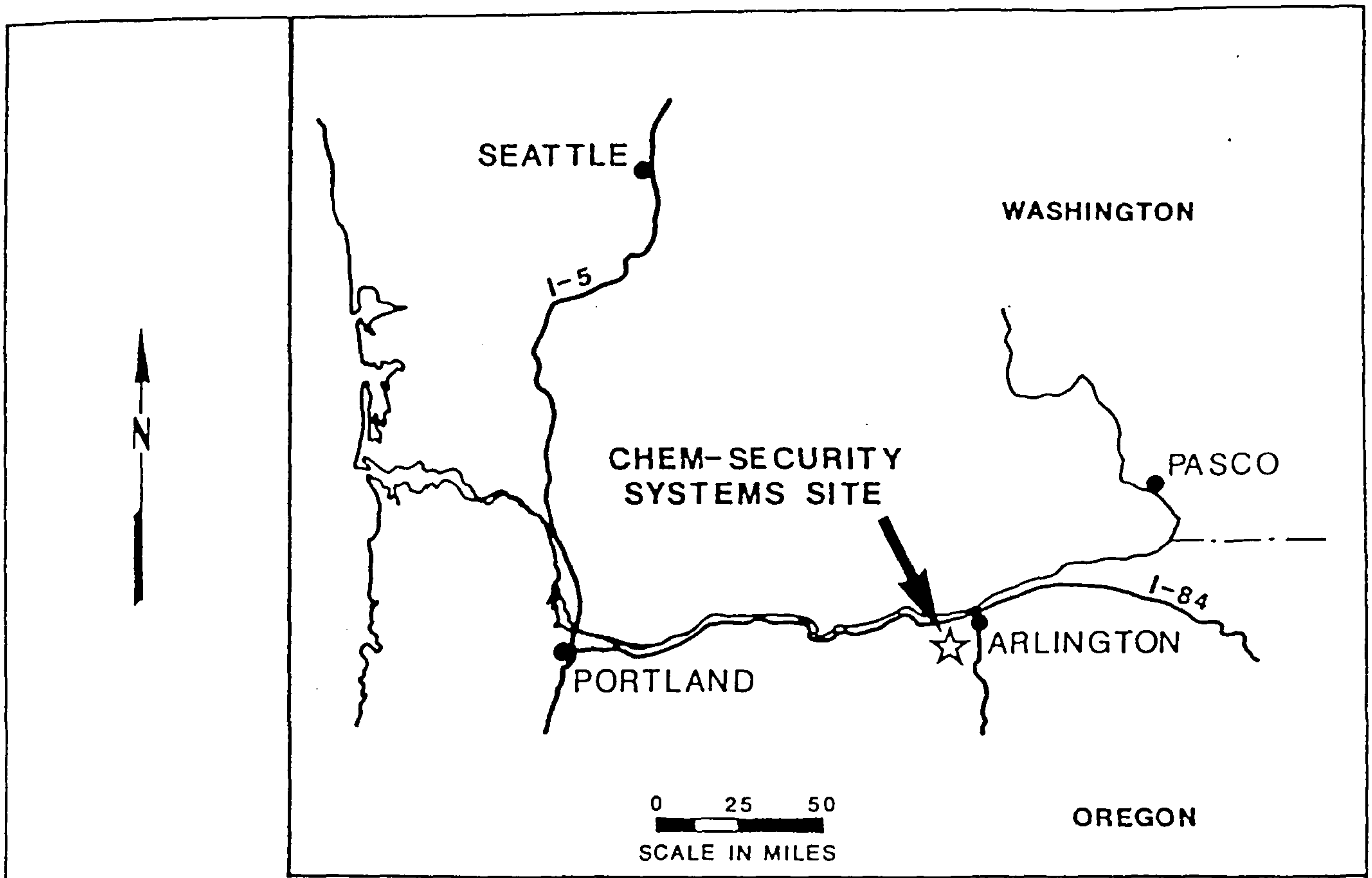
Although the concentration of hazardous substances may rise above background, it may not rise higher than is necessary to find a solution that is feasible and will protect public health and the environment.

Public Notice and Participation

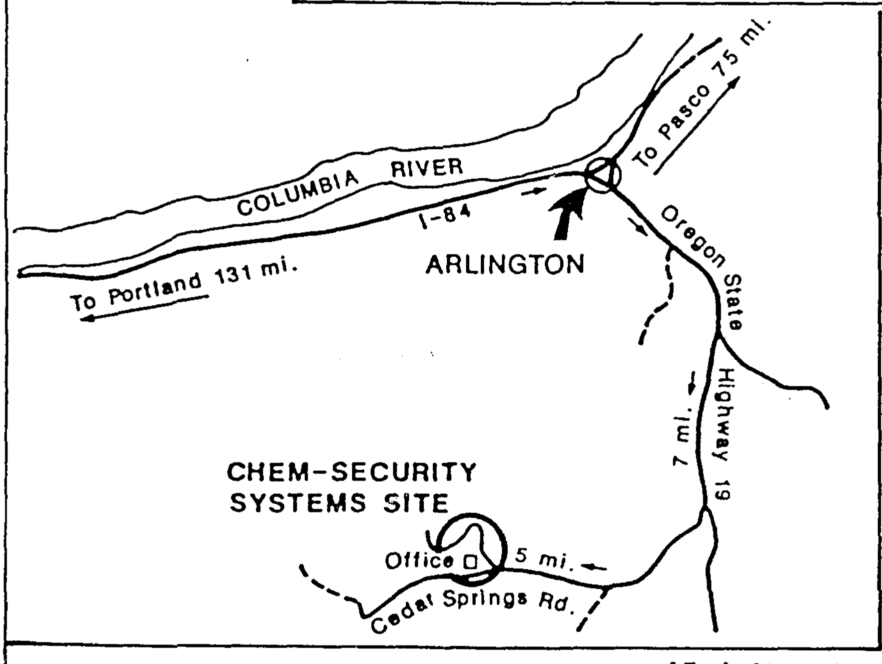
Before approving a remedial action, the Department will notify the public and provide opportunity to comment. All public comments must be considered before a decision is made. The public notice will include a brief description of the preferred remedial action option and will be published in a local newspaper and in the Secretary of State's Bulletin. The Department will also identify and notify interested community organizations.

For more information about Oregon's Environmental Cleanup Program and the Environmental Cleanup Rules, contact the Environmental Cleanup Division at 503-229-5733 or call tollfree in Oregon at 1-800-452-4011.

September 1988



Location Map

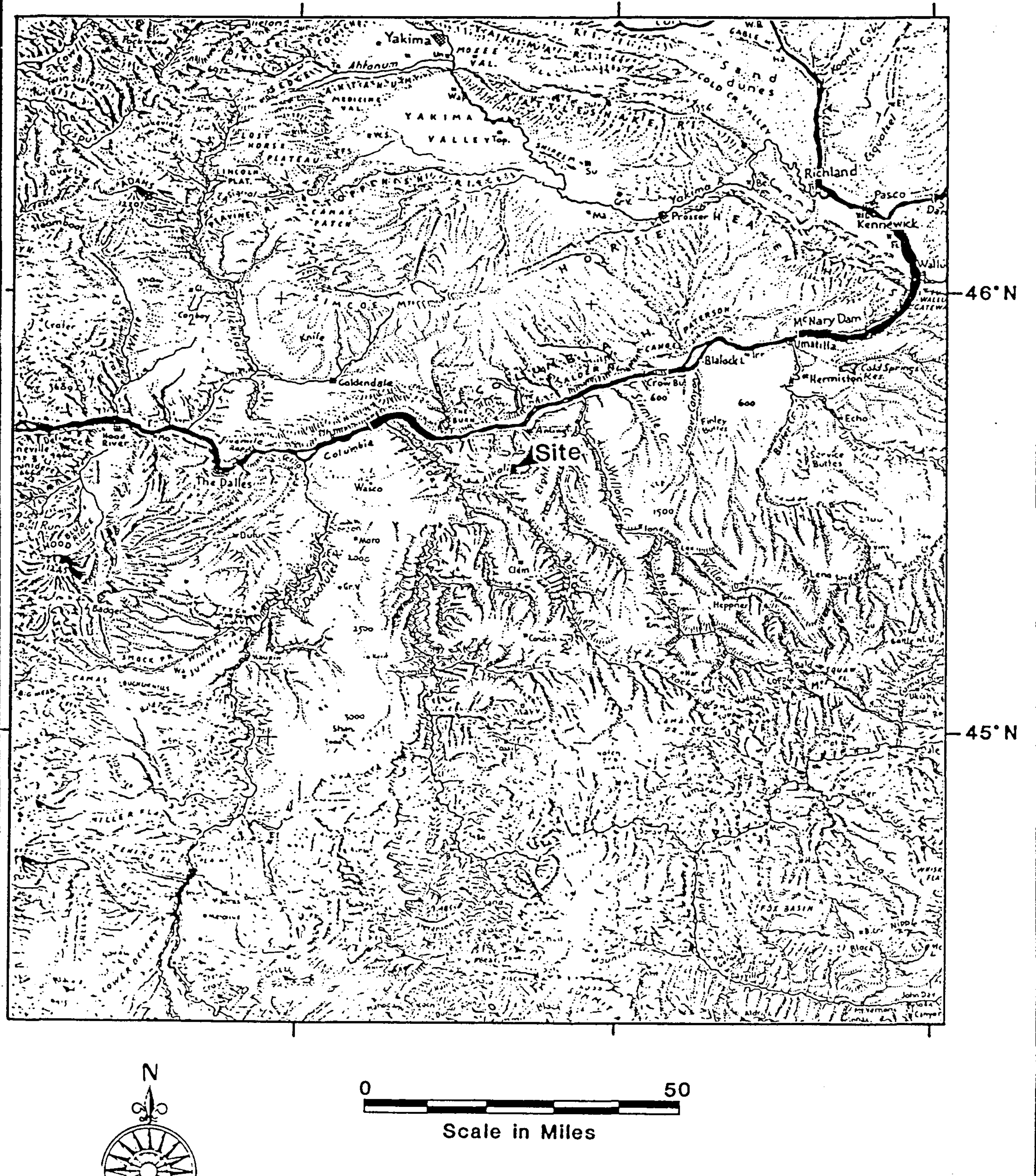


Vicinity Map

FIGURE 1

PROJECT LOCATION MAP

CSSI



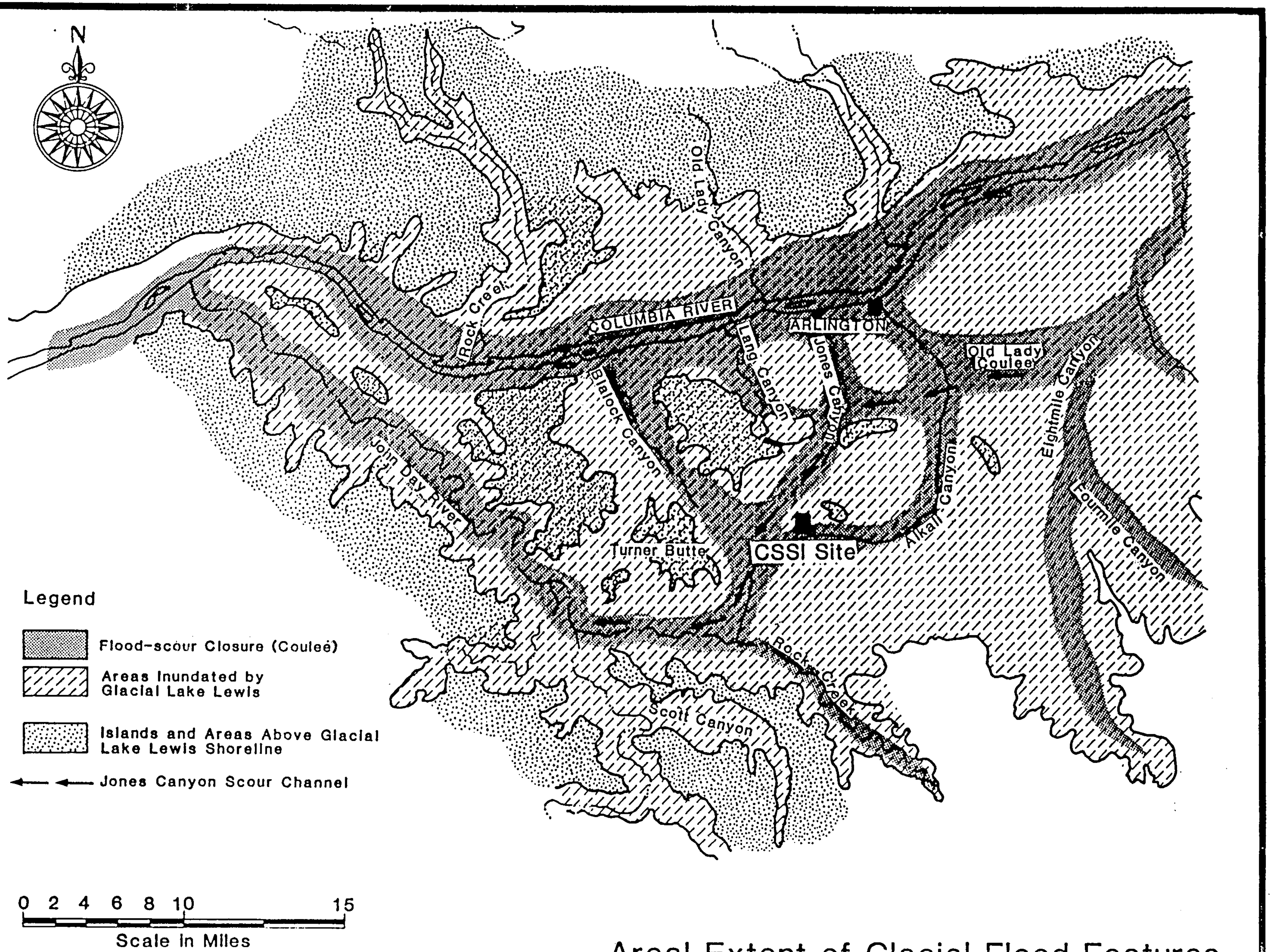
Regional Physiographic Map

Dames & Moore

Modified from "Landforms of the Northwestern States" by Erwin Raisz, 1965.

Job No. 7722-179-05

Figure 5-

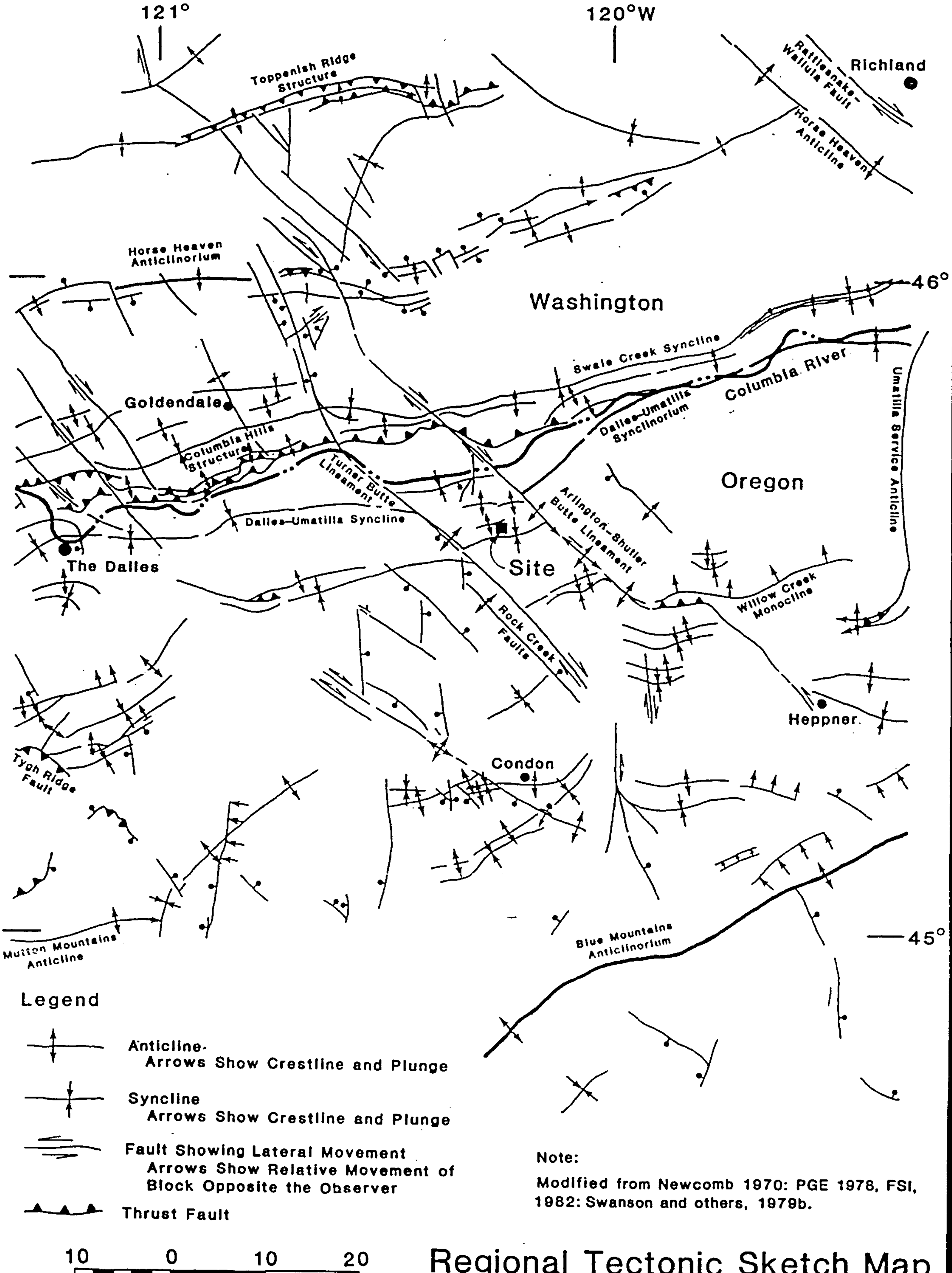


Areal Extent of Glacial Flood Features

Dames & Moore

Job No. 7722-179-05

Figure 5-



Note:

Modified from Newcomb 1970: PGE 1978, FSI, 1982: Swanson and others, 1979b.

Regional Tectonic Sketch Map

Dames & Moore

Job No. 7722-179-05

Figure 5-6

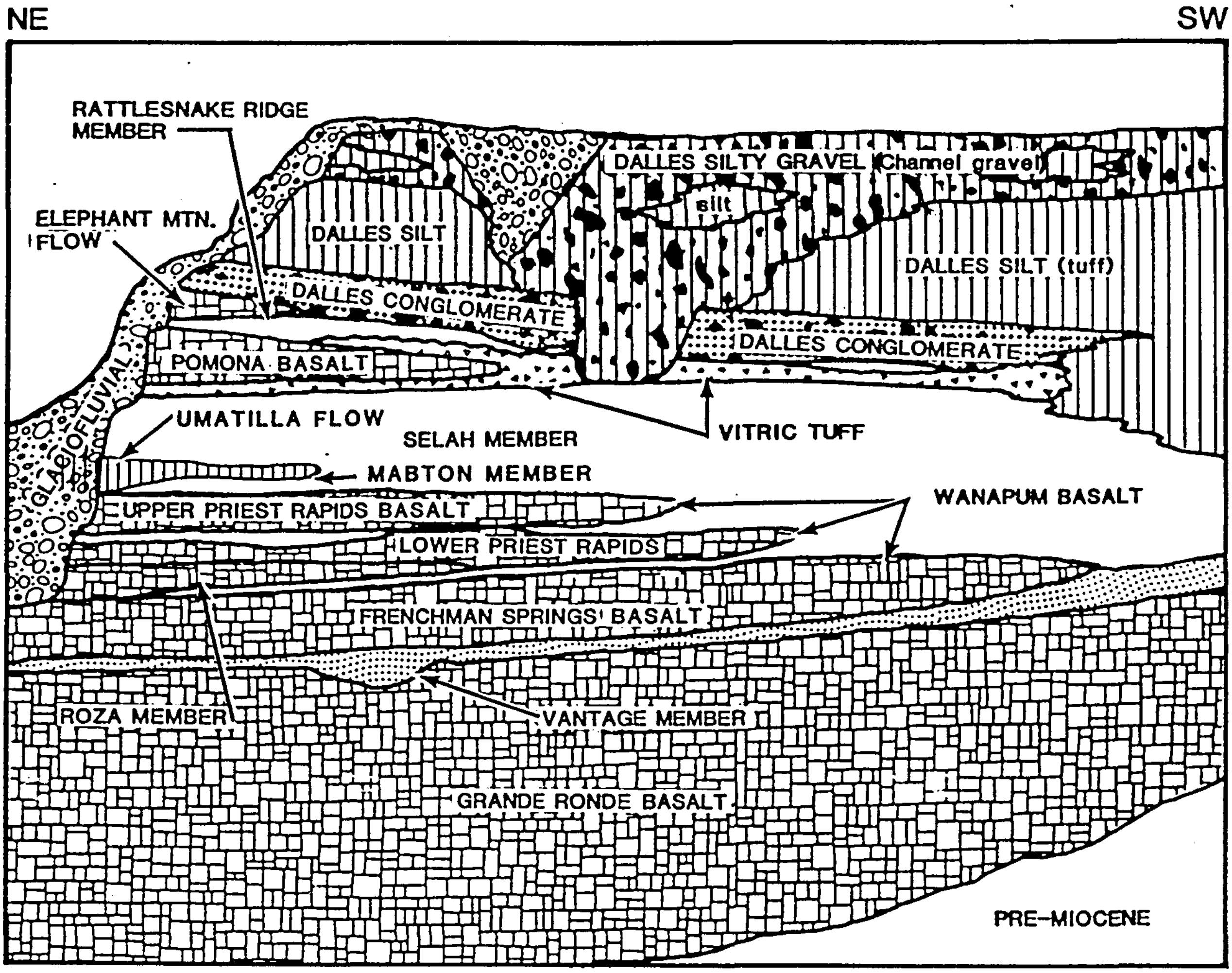
PERIOD		EPOCH	AGE	GEOLOGIC UNIT (Common Name)	LITHOLOGY	STRATIGRAPHY		
Tertiary	Quaternary	Holocene	Recent	Loess	Silt and fine sand of Eolian origin			
Tertiary	Quaternary	Holocene	Recent	Alluvium	Sand, gravel and silt water-laid			
Tertiary	Quaternary	Holocene	Recent	Colluvium	Slope wash-silt, sand and rock fragments			
Tertiary	Quaternary	Pleisto-cene	<1.6 mil. years	Flood Gravels	Sand and gravel, some silt, some caliche			
Tertiary	Neogene	Pliocene	1.6-5.3 million years	Channel Unit	Poorly sorted silty gravel	Dalles Formation		
Tertiary	Neogene	Pliocene	1.6-5.3 million years	Upper Tuff Unit	Tan to light green, massive, very soft	Dalles Formation		
Tertiary	Neogene	Pliocene	1.6-5.3 million years	Conglomerate Unit	Poorly to moderately indurated conglomerate	Dalles Formation		
Tertiary	Neogene	Pliocene	1.6-5.3 million years	Rattlesnake Ridge Member	Weathered tuff	Ellensburg Formation		
Tertiary	Neogene	Miocene	12 million years	Pomona Basalt	Dark gray, very hard, massive, fine grained, occasionally vesicular	Saddle Mountains Basalt Formation	Yakima Basalt Subgroup	Columbia River Basalt Group
Tertiary	Neogene	Miocene	12 million years	Vitric Tuff Unit	Light buff to cream, very soft	Ellensburg Formation	Yakima Basalt Subgroup	Columbia River Basalt Group
Tertiary	Neogene	Miocene	12 million years	Selah Member	Tuffaceous siltstone (some clay and sand interbeds), light olive green, very soft to soft	Ellensburg Formation	Yakima Basalt Subgroup	Columbia River Basalt Group
Tertiary	Neogene	Miocene	13.6 million years	Priest Rapids Basalt (Upper Flow)	Dark gray, massive, fine grained, occasionally vesicular, very hard	Wanapum Formation	Yakima Basalt Subgroup	Columbia River Basalt Group
Tertiary	Neogene	Miocene	13.6 million years	Priest Rapids Interbed	Tuffaceous vitric to lithic tuff, light olive green, very soft to soft	Wanapum Formation	Yakima Basalt Subgroup	Columbia River Basalt Group
Tertiary	Neogene	Miocene	13.6 million years	Priest Rapids Basalt (Lower Flow)	Dark gray, massive, fine grained, occasionally vesicular, very hard	Wanapum Formation	Yakima Basalt Subgroup	Columbia River Basalt Group
Tertiary	Neogene	Miocene	13.6 million years	Frenchman Springs Basalt Member	Dark gray, massive, fine grained, occasionally vesicular, very hard	Wanapum Formation	Yakima Basalt Subgroup	Columbia River Basalt Group
Tertiary	Neogene	Miocene	13.6 million years	Grande Ronde Basalt	Dark gray, massive, fine grained, occasionally vesicular, very hard	Grande Ronde Fm	Yakima Basalt Subgroup	Columbia River Basalt Group

Key: ⁚⁚⁚⁚⁚ Unconformity

Generalized Stratigraphic Column

Job No. 7722-179-05

Figure 5-3



Generalized Regional Stratigraphic Diagram
Arlington–The Dalles Area, Oregon

Dames & Moore

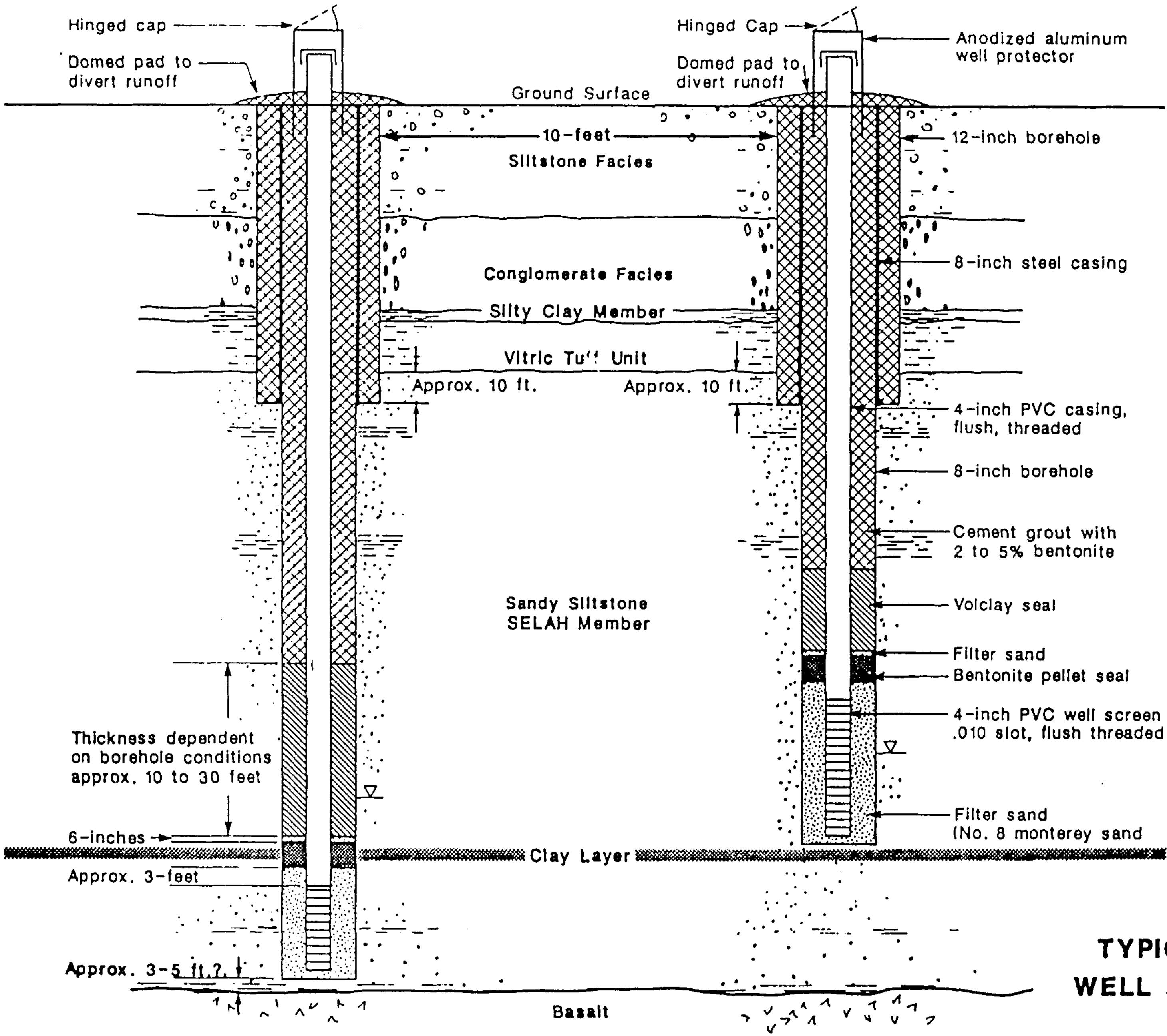


FIGURE 4

TYPICAL MULTIPLE WELL INSTALLATION

CSSI

PROJECT NO. 873-1254-004 DWG NO. 6106 DATE 11/2/87 DRAWN CB APPROVED BP

Golder Associates

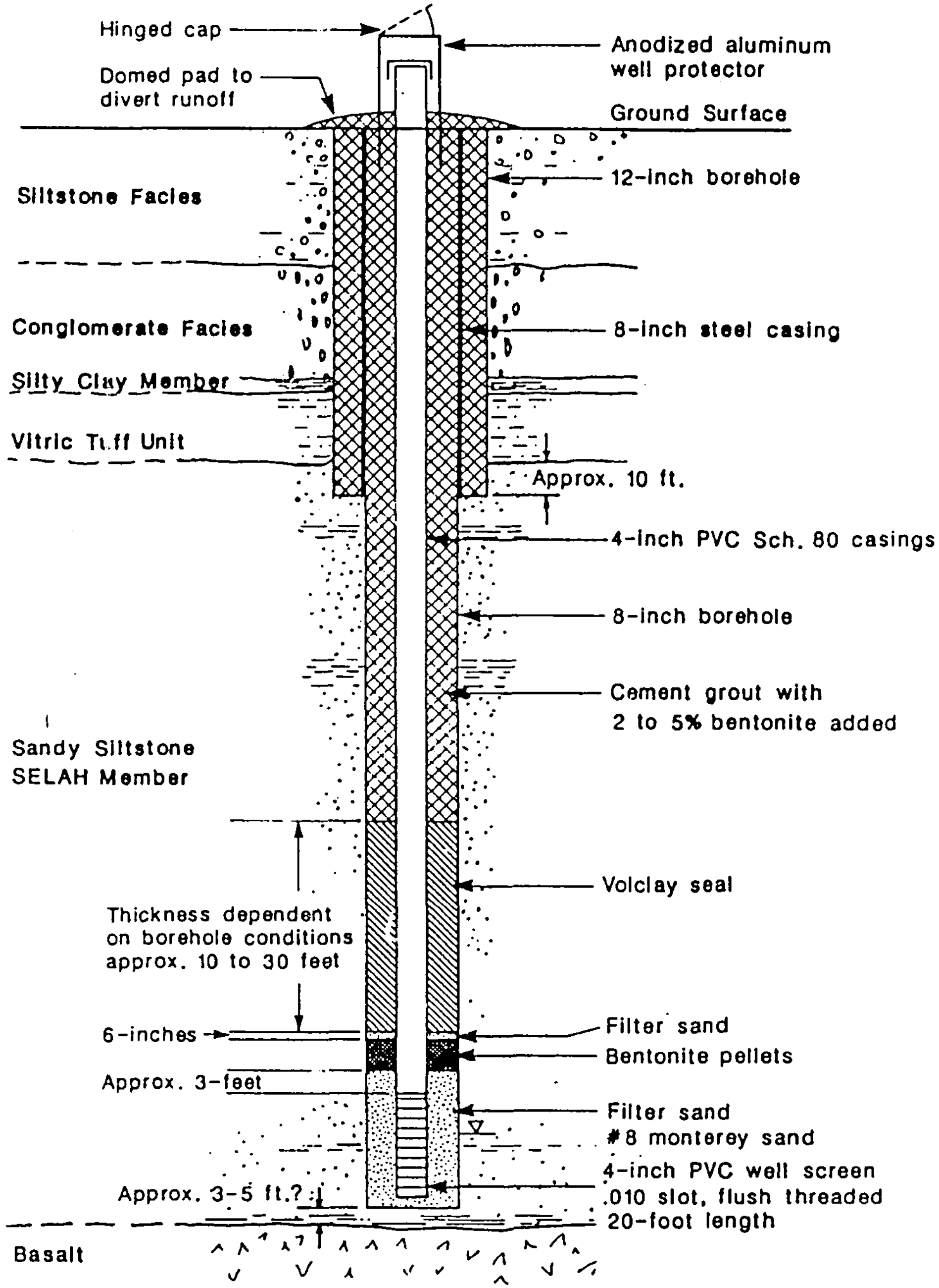


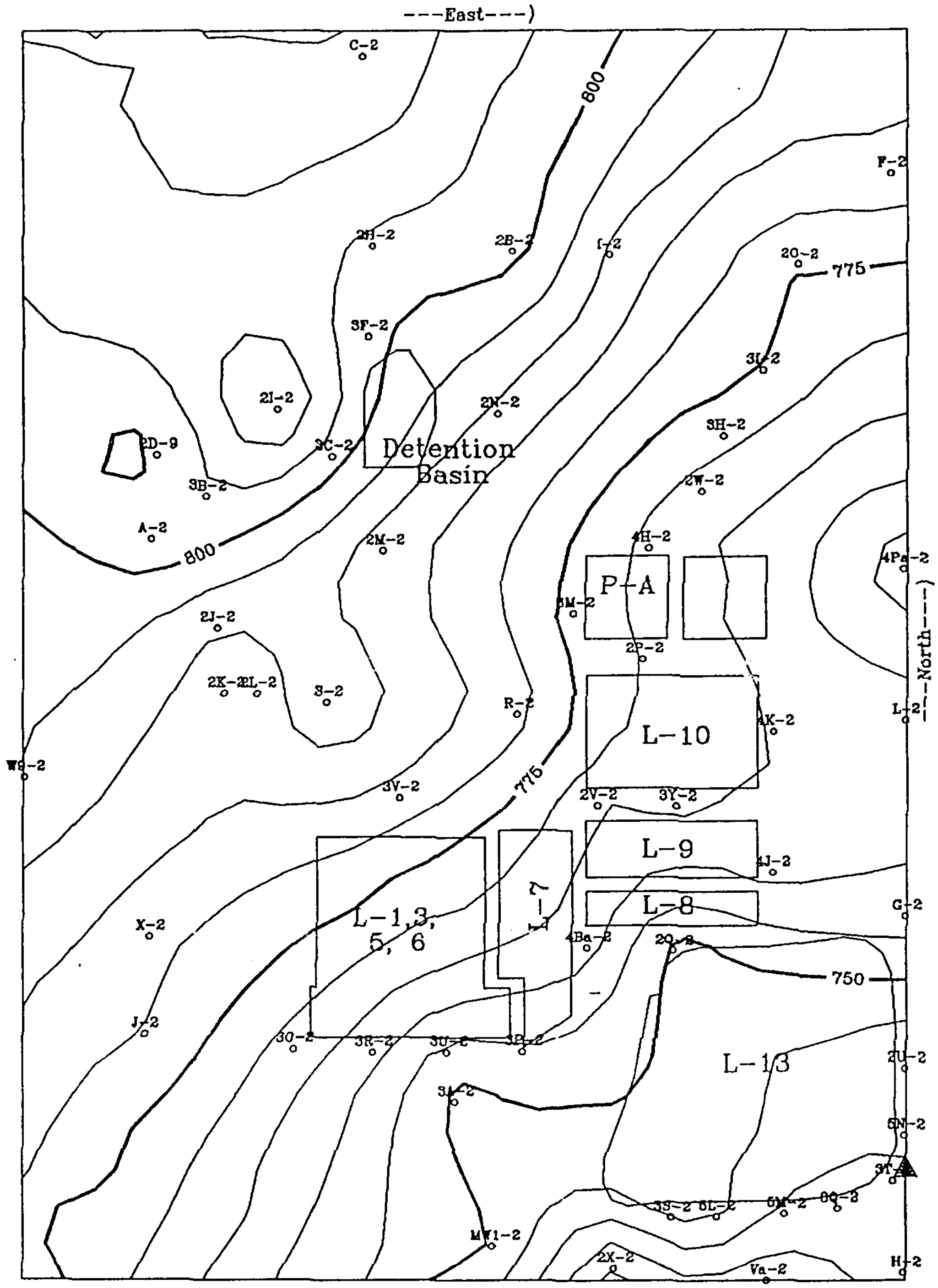
FIGURE 3

TYPICAL SINGLE WELL INSTALLATION

CSSI

PROJECT NO 873-1254-004 DWG NO 6105 DATE 11/2/87 DRAWN CB APPROVED BP

Golder Associates



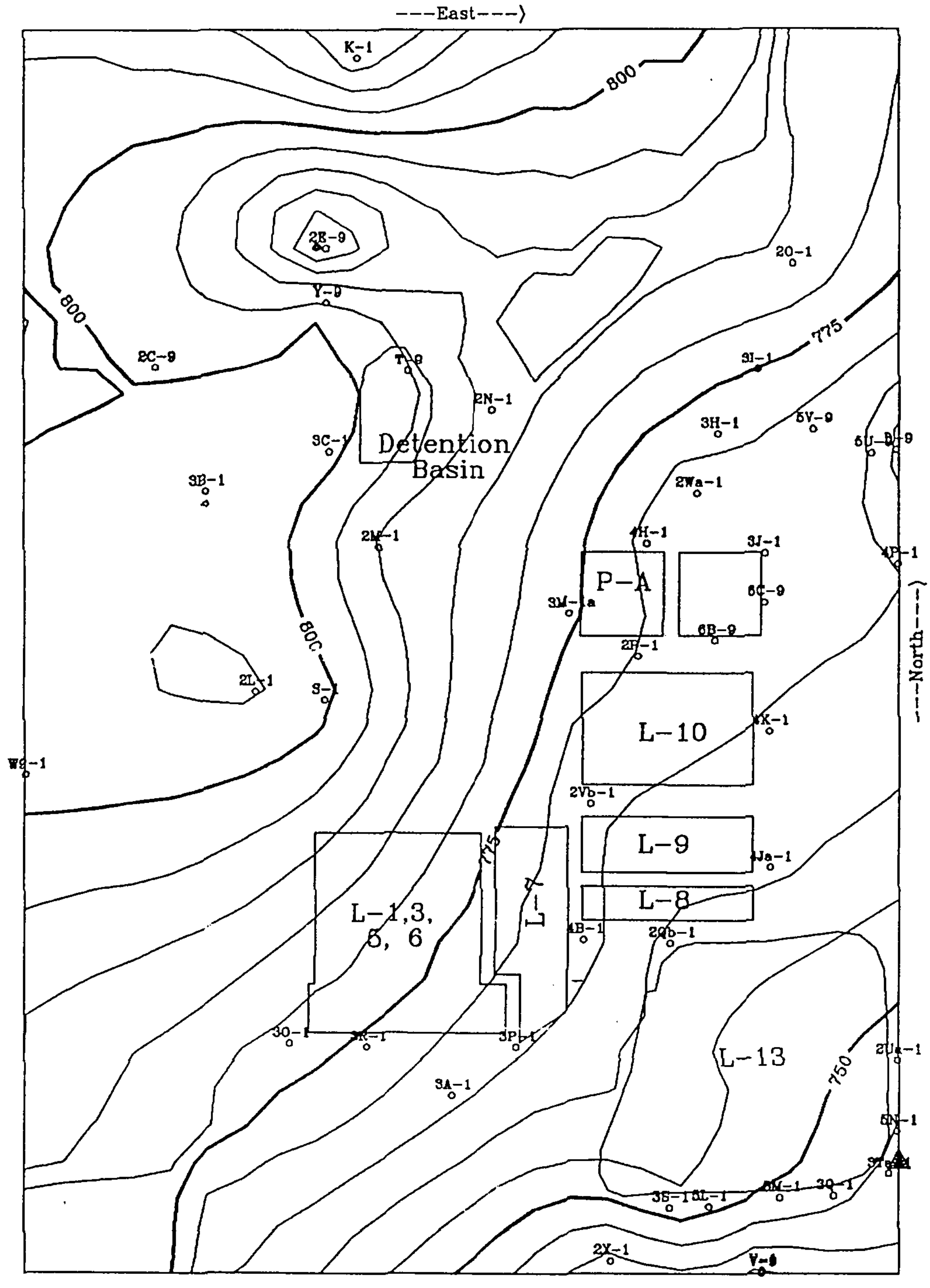
Groundwater Elevations are units of feet above mean sea level or ft msl at 5-foot contour intervals.

SCALE 1 inch 400 feet

CHEM-SECURITY SYSTEMS, INC., ARLINGTON, OR

GROUNDWATER ELEVATION CONTOUR MAP
Level 2 Selah Aquifer Wells and Piezometers

MARCH 1989



Groundwater Elevations are units of feet above mean sea level or ft msl at 5-foot contour intervals.

SCALE 1 inch 400 feet

CHEM-SECURITY SYSTEMS, INC., ARLINGTON, OR

GROUNDWATER ELEVATION CONTOUR MAP
Level 1 Selah Aquifer Wells and Piezometers

MARCH 1989

TABLE 6-1

RCRA GROUNDWATER SAMPLING PARAMETERS

Indicator Parameters

- Volatile organic compounds

Benzene
Bromoform
Carbon tetrachloride
Chlorobenzene
Chlorodibromomethane
Chloroethane
2-Chloroethylvinyl ether
Chloroform
Dichlorobromomethane
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethylene
1,2-Dichloropropane
cis-1,3-Dichloropropylene
trans-1,3-Dichloropropylene
Ethylbenzene
Bromomethane
Chloromethane
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
Toluene
trans-1,2-Dichloroethylene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethylene
Trichlorofluoromethane
Vinyl chloride

Field Measurements – RCRA & TSCA

- pH
- Specific conductivity
- Temperature
- Depth to water
- GROUNDWATER ELEVATION
- WELL ELEVATION

Supplemental Parameters

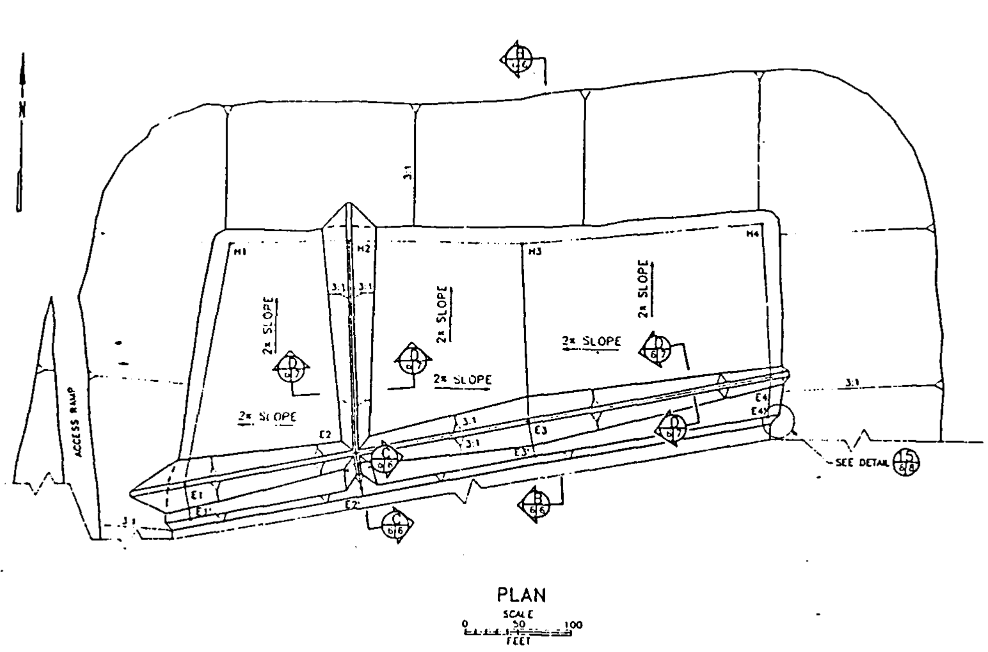
- Chromium, dissolved
- Copper, dissolved
- Arsenic, dissolved
- Cadmium, dissolved
- Cyanide, total

Methylene chloride is a known laboratory contaminant and will not be used as an indicator parameter.

8631144000/MON WELL RPT/TAB61/487

TSCA

- TOX
- Chloride, Total
- PCB (6 Aroclors)



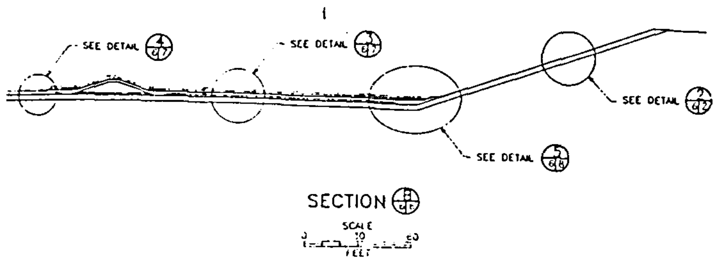
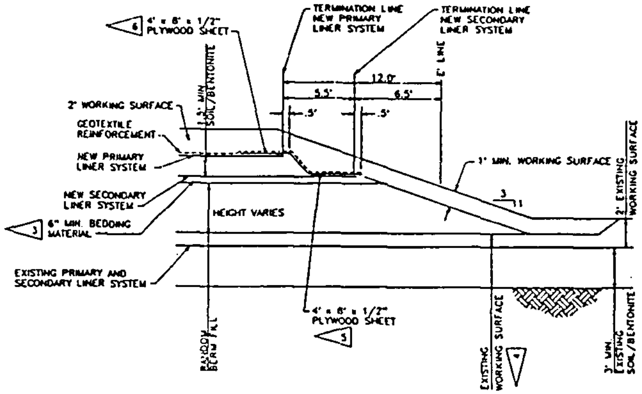


TABLE 2. FINAL SURFACE ELEVATIONS

POINT	DISTANCE IN FEET FROM SECTION CORNER LOCATED AT S.E. CORNER OF L-13		ELEVATION OF TOP OF WORKING SURFACE AFTER EXCAVATION (FEET)	ELEVATION OF TOP OF SOIL/BENTONITE PRIMARY LINER (FEET)	ELEVATION OF FINAL GRADE: TOP OF WORKING SURFACE (FEET)
	NORTH	WEST			
E1'	368.5	757.2	911.5	913.0	915.0
E2'	400.0	596.1	914.8	916.3	918.3
E3'	431.6	433.6	911.5	913.0	915.0
E4'	471.4	215.5	916.0	917.5	919.5
E1	400.9	763.5	912.2	920.5	922.5
E2	432.4	602.5	915.5	920.5	922.5
E3	464.0	440.0	912.2	920.5	922.5
E4	508.3	212.4	916.8	920.5	922.5
H1	627.6	723.7	909.4	910.9	912.9
H2	631.5	611.0	911.5	920.5	922.5
H3	630.5	448.0	908.9	910.4	912.4
H4	652.6	222.3	913.1	914.6	916.6



DIVIDER BERM TERMINATION SECTION

SCALE
0 4 8
FEET

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL MATERIAL AND WORKMANSHIP PER SPECIFICATIONS.
2. SYNTHETIC MATERIALS NOT SHOWN TO SCALE.
3. TOP OF BERM (BEDDING MATERIAL) AT CONSTANT ELEVATION OF 919.0 FEET BEFORE INSTALLATION OF NEW SECONDARY LINER
4. EXCAVATE EXISTING W[illegible] SURFACE TO ELEVATIONS LISTED IN TABLE 2. [illegible]MATELY ONE FOOT OF WORKING SURFACE W[illegible] REMAIN AFTER EXCAVATION.
5. PLACE PLYWOOD SHE[illegible] OF GEOSYNTHETIC MATERIALS ALONG [illegible] LINER SYSTEM TERMINATION LINE CONTIN[illegible] A DISTANCE OF 24 FEET ON EACH SIDE [illegible] AS SHOWN ON SECTION C, [illegible]HEET [illegible] OF PLYWOOD SHEETS A MINIMUM [illegible]
6. PLACE PLYW[illegible] OF GEOSYNTHETIC MATERIALS [illegible] EXTENT OF [illegible]W PRIMARY LINER SYSTEM [illegible] AS SHOWN [illegible] SECTION C, SHEET 6 A[illegible] OVERLA[illegible]NDS OF PLYWOOD SHE[illegible] 6 INCHES.

Dames & Moore

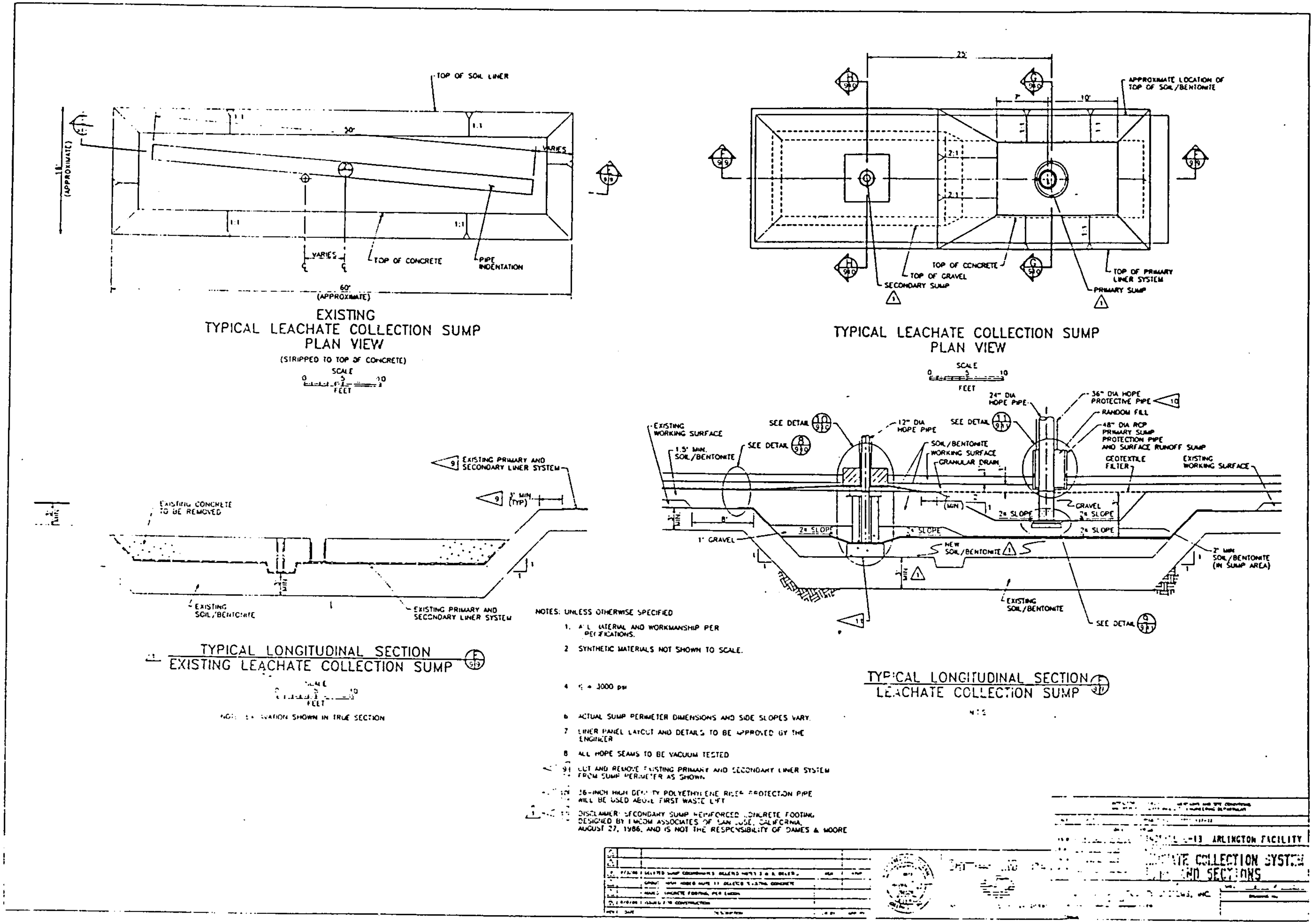
[illegible] STRUCTURES DESIGN GROUP

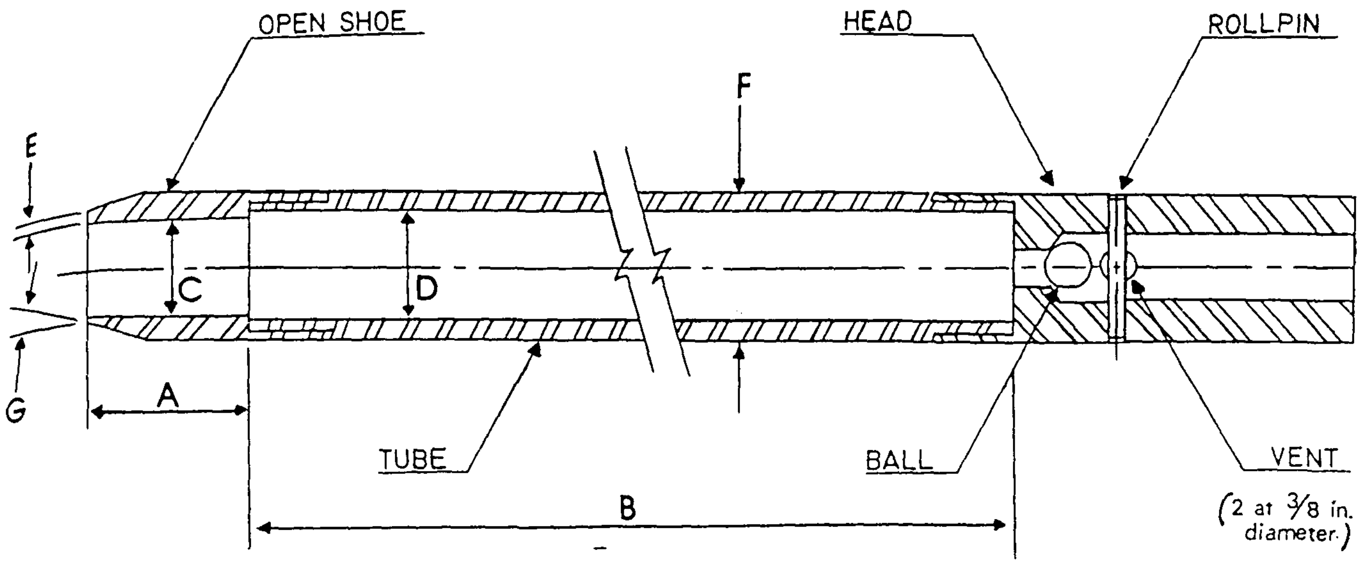
LANDFILL L-13 ARLINGTON FACILITY

FINAL PLAN

CHEM-SECURITY SYSTEMS, INC.

EXHIBIT 6E-6


TOP OF SOIL LINER
30'
VARIES
18' (APPROXIMATE)
TOP OF CONCRETE
PIPE INDENTATION
60' (APPROXIMATE)
EXISTING
TYPICAL LEACHATE COLLECTION SUMP
PLAN VIEW
(STRIPPED TO TOP OF CONCRETE)
SCALE
FEET
25'
10'
APPROXIMATE LOCATION OF TOP OF SOIL/BENTONITE
2:1
TOP OF CONCRETE
TOP OF GRAVEL
SECONDARY SUMP
TOP OF PRIMARY LINER SYSTEM
PRIMARY SUMP
TYPICAL LEACHATE COLLECTION SUMP
PLAN VIEW
EXISTING PRIMARY AND SECONDARY LINER SYSTEM
EXISTING CONCRETE TO BE REMOVED
EXISTING SOIL/BENTONITE
EXISTING PRIMARY AND SECONDARY LINER SYSTEM
TYPICAL LONGITUDINAL SECTION
EXISTING LEACHATE COLLECTION SUMP
EXISTING WORKING SURFACE
1.5' MIN. SOIL/BENTONITE
SEE DETAIL
12" DIA HDPE PIPE
SOIL/BENTONITE WORKING SURFACE
GRANULAR DRAIN
24" DIA HDPE PIPE
36" DIA HDPE PROTECTIVE PIPE
RANDOM FILL
48" DIA RCP PRIMARY SUMP PROTECTION PIPE AND SURFACE RUNOFF SUMP
GEOTEXTILE FILTER
EXISTING WORKING SURFACE
1' GRAVEL
2% SLOPE
GRAVEL
NEW SOIL/BENTONITE
2' MIN SOIL/BENTONITE (IN SUMP AREA)
EXISTING SOIL/BENTONITE
TYPICAL LONGITUDINAL SECTION
LEACHATE COLLECTION SUMP
NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL MATERIAL AND WORKMANSHIP PER SPECIFICATIONS.
2. SYNTHETIC MATERIALS NOT SHOWN TO SCALE.
4. f'c = 3000 psi
6. ACTUAL SUMP PERIMETER DIMENSIONS AND SIDE SLOPES VARY.
7. LINER PANEL LAYOUT AND DETAILS TO BE APPROVED BY THE ENGINEER
8. ALL HDPE SEAMS TO BE VACUUM TESTED
9. CUT AND REMOVE EXISTING PRIMARY AND SECONDARY LINER SYSTEM FROM SUMP PERIMETER AS SHOWN.
10. 36-INCH HIGH DENSITY POLYETHYLENE RISER PROTECTION PIPE WILL BE USED ABOVE FIRST WASTE LIFT
11. DISCLAIMER: SECONDARY SUMP REINFORCED CONCRETE FOOTING DESIGNED BY EMCON ASSOCIATES OF SAN JOSE, CALIFORNIA, AUGUST 27, 1986, AND IS NOT THE RESPONSIBILITY OF DAMES & MOORE
ARLINGTON FACILITY
COLLECTION SYSTEM
SECTIONS



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 − 0.00 in. (38.1 ± 1.3 − 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 − 0.00 in. (50.8 ± 1.3 − 0.0 mm)
G = 16.0° to 23.0°

The 1½ in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retainers may be used to retain soil samples.

FIG. 2 Split-Barrel Sampler

intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 mm) or less in homogeneous strata with test and sampling locations at every change of strata.

6.2 Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures have proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable borings. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the boring below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a boring with bottom discharge bits is not permissible. It is not permissible to advance the boring for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the boring or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the boring has been advanced to the desired sampling elevation and excessive cuttings have been removed, prepare for the test with the following sequence of operations.

7.1.1 Attach the split-barrel sampler to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the boring and apply a seating blow. If excessive cuttings are encountered at the bottom of the boring, remove the sampler and sampling rods from the boring and remove the cuttings.

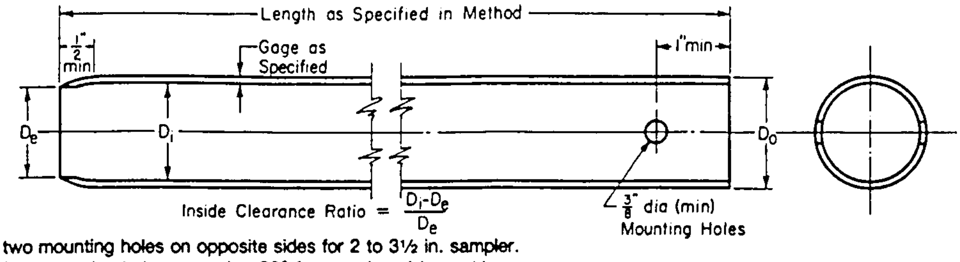
7.1.4 Mark the drill rods in three successive 6-in. (0.15-m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-in. (0.15-m) increment.

7.2 Drive the sampler with blows from the 140-lb (63.5-kg) hammer and count the number of blows applied in each 6-in. (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 6-in. (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.



NOTE 1—Minimum of two mounting holes on opposite sides for 2 to 3½ in. sampler.
NOTE 2—Minimum of four mounting holes spaced at 90° for samplers 4 in. and larger.
NOTE 3—Tube held with hardened screws.
NOTE 4—Two-inch outside-diameter tubes are specified with an 18-gage wall thickness to comply with area ratio criteria accepted for "undisturbed samples." Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gage tubes are generally readily available.

Metric Equivalents

in.	mm
⅜	6.77
½	12.7
1	25.4
2	50.8
3½	88.9
4	101.6

FIG. 1 Thin-Walled Tube for Sampling

TABLE 1 Suitable Thin-Walled Steel Sample Tubes[A]

utside diameter:			
in.	2	3	5
mm	50.8	76.2	127
all thickness:			
Bwg	18	16	11
in.	0.049	0.065	0.120
mm	1.24	1.65	3.05
ube length:			
in.	36	36	54
m	0.91	0.91	1.45
learance ratio, %	1	1	1

[A] The three diameters recommended in Table 1 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions.

TABLE 2 Dimensional Tolerances for Thin-Walled Tubes

Nominal Tube Diameters from Table 1[A] Tolerances, in.			
Size Outside Diameter	2	3	5
utside diameter	+0.007 −0.000	+0.010 −0.000	+0.015 −0.000
side diameter	+0.000 −0.007	+0.000 −0.010	+0.000 −0.015
all thickness	±0.007	±0.010	±0.015
vality	0.015	0.020	0.030
raightness	0.030/ft	0.030/ft	0.030/ft

[A] Intermediate or larger diameters should be proportional. Tolerances shown are essentially standard commercial manufacturing tolerances for seamless steel mechanical tubing. Specify only two of the first three tolerances; that is, O.D. and I.D., or O.D. and Wall, or I.D. and Wall.

ossible to avoid disturbance of the material to be sampled.

NOTE 2—Roller bits are available in downward-jetting and diffused-jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

6.3 Place the sample tube so that its bottom rests on the ottom of the hole. Advance the sampler without rotation by continuous relatively rapid motion.

6.4 Determine the length of advance by the resistance and ondition of the formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays.

NOTE 3—Weight of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 1.

6.5 When the formation is too hard for push-type insertion, the tube may be driven or Practice D 3550 may be used. Other methods, as directed by the engineer or geologist, may be used. If driving methods are used, the data regarding weight and fall of the hammer and penetration achieved must be shown in the report. Additionally, that tube must be prominently labeled a "driven sample."

6.6 In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3 in. for sludge-end cuttings.

NOTE 4—The tube may be rotated to shear bottom of the sample after pressing is complete.

6.7 Withdraw the sampler from the formation as carefully as possible in order to minimize disturbance of the sample.

7. Preparation for Shipment

7.1 Upon removal of the tube, measure the length of sample in the tube. Remove the disturbed material in the upper end of the tube and measure the length again. Seal the upper end of the tube. Remove at least 1 in. of material from the lower end of the tube. Use this material for soil description in accordance with Practice D 2488. Measure the overall sample length. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed without removal of soil from the ends of the tube if so directed by the engineer or geologist.

NOTE 5—Field extrusion and packaging of extruded samples under the specific direction of a geotechnical engineer or geologist is permitted.
NOTE 6—Tubes sealed over the ends as opposed to those sealed with expanding packers should contain end padding in end voids in order to prevent drainage or movement of the sample within the tube.

7.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample. Assure that the

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GUIDELINES FOR MONITORING WELL DESIGN, INSTALLATION, TESTING, DECOMMISSIONING AND RECORD KEEPING, INCLUDING STANDARDS FOR DRILLING AND CONSTRUCTING MONITORING WELLS

I. Introduction

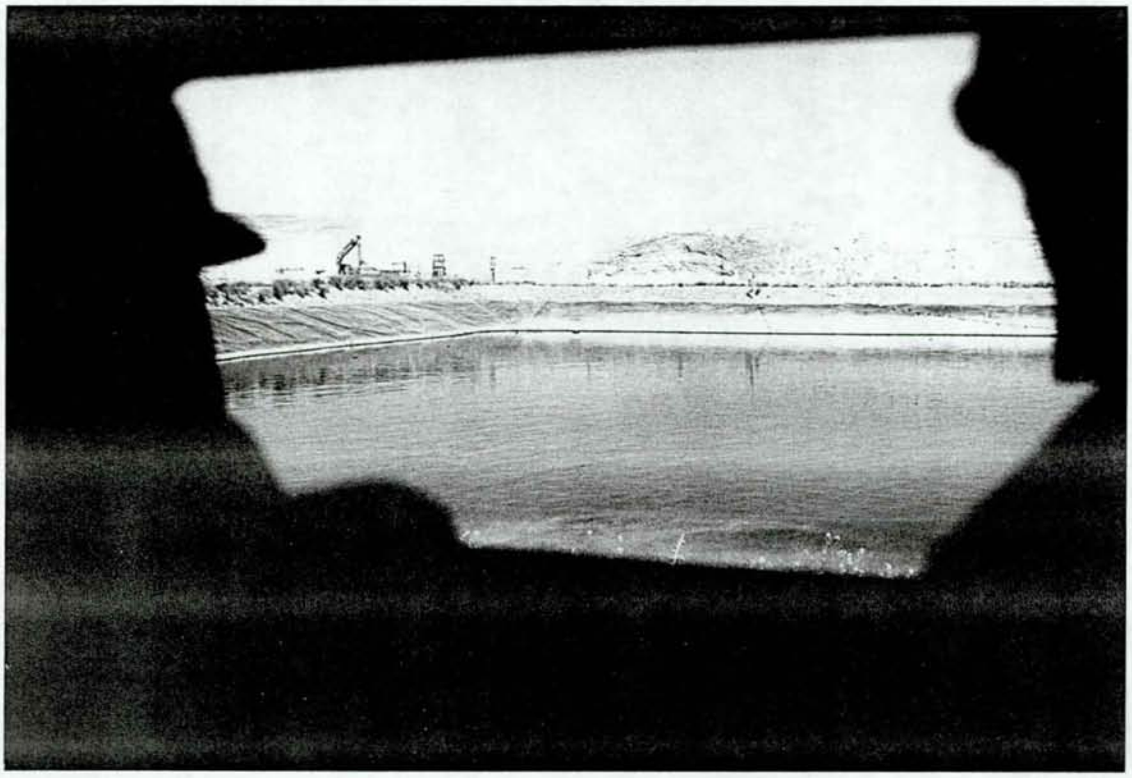
Monitoring wells should be designed, located, installed and maintained so as to obtain reliable and representative information regarding aquifer characteristics, groundwater flow directions, and chemical and physical characteristics of groundwater.

Monitoring well design and construction should:

(1) Include consideration of site specific hydrogeologic information from the results of a preliminary site investigation.

(2) Be compatible with site specific hydrogeologic conditions, including the physical and chemical properties of the groundwater and any contaminants known or suspected to be present in the groundwater.

(3) Prevent introduction of surface contaminants into groundwater, prevent vertical movement of water or contaminants between water-bearing zones in either the well bore or well



Fordamping av spesialavfall i åpne bassenger.
Arlington. Oregon. USA. Juni 1989.

Deponi for lagring av spesialavfall
Arlington, Oregon, USA. Juni 1989.