GRUMMAN – NAVY

16

B-36

Aug 20, 1991

J. Barnes arrives on-site at 10[45] am.
Weather: cloudy - off-on rain
T = 75°F.

11[00] Cont'd find survey crew.
Seen at Plot 16 for 30 min.
Down at Plot 35 - meet
with G. De Bono and J. Wright

11[30] See a Target van leave site.

11[30]-11[45] J. Barnes goes to Sta. 20 location.

11[53] Arrive at Site 2 on New property. 2 Target vans at location.

Mike Mancke - Target
Everyone else out to lunch.
No work done yet. There
was a health & safety
meeting this morning.
Mike performing 3pt calibration.

Aug 20, 1991

12-12[15] S. Barnes goes to Pl. 16 to make phone call and then went out for lunch.

12[40] Crew return

Nelson ~~Stoudt~~ Stammer
Jason Coates
Steve Sybert
John Brogden
Dan Coleman
} Target

Kevin Kilmartin
Fred Ranser
} NUS

12[53] Soil gas crew continuing calibration tasks. K. Kilmartin leaves staging area.

GC: ECD in ~~series~~ parallel w/a flame ionization detector.

Column 30 meters long { ECD - Supelco 1.5 μ
FID - Supelco .53 μ ↑ film thickness

T: 35°C for 2 min
then 10°C/min → 115°
then 40°C/min → 145°C

1:45 Target personnel begin donning tyvek suits and tapping up.

Aug 20, 1991

2:15 Mobilizing at Site #1

Location 104 Jay St, Steve and Dan

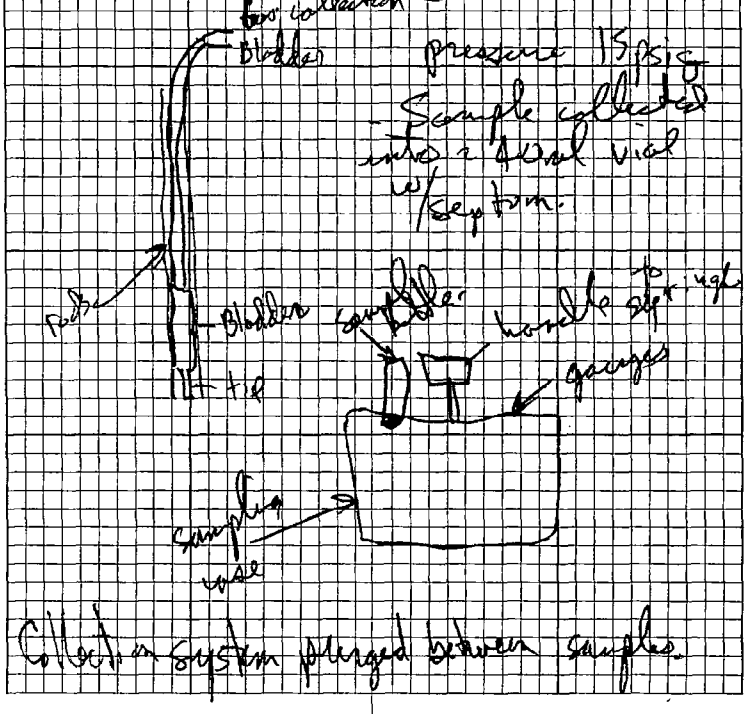
Start driving rods into ground (2:27 pm)

Rods - 5' Long 1" Dia

Collected 5' Sample at 2:32.

2nd Rods hammered down at 1'06

Sampling apparatus:



Collection system plunged between samples.

Aug 20, 1991

Purge w/air. Check purging w/ a blank after 20 samples.

Pump - 046503 (Mar)
Set up at location 106

3:10
The other sampling crew is sampling at #103

#103 Probe down 15' at 3:23
Crew starting to collect sample

3:42 Crew preparing to sample 5' depth after pounding 25' of rod into ground.
Soil jar hole filled w/ powder beaten, etc.

3:49 Advised K. Kilmartin to sample dyed H_2O supply and have it analyzed prior to commencing drilling operations

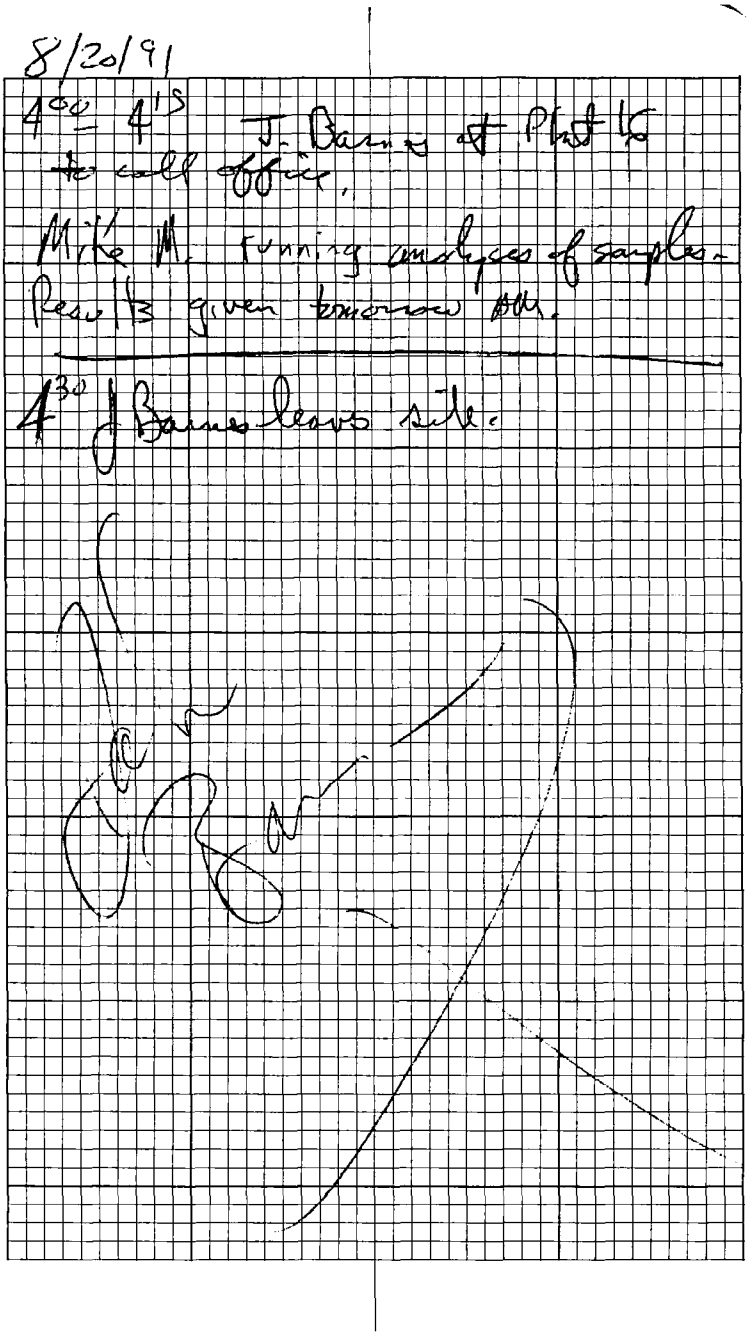
Other crew finishing point 103.

8/20/91

4⁰⁰ – 4¹⁵ J. Barnes at Plot 15 ~~the call office~~.

Mike M. running analyses of samples. Results given tomorrow AM.

4³⁰ J Barnes leaves site.



Aug 21, 1991

J. Barnes arrives at 8[15]am after visiting GM-20 location.

Kevin Kilmartin on-site - checking utilities. Target not here. Fred Ranaw is at at Area 1.

Weather - Sprinkling T= 70°F.
Forecast: clearing T= 85°F

8[35] Target personnel begin to arrive at staging area.

8[40] Target personnal arrive at Derrom pad.

9:15 Spoke w/ K. Kilmartin - suggested that survey be moved to Area 3 instead of Area 1 due to rainfall - Area 3 is paved, and ∴ survey should work.

9:30 Spoke w/ Maureen Sanfilippi - she agreed w/ my assessment of the situation.

9:40 Back to Navy prop - Target mobilizing on Area 3.

9:45 Steve & Dan preparing to drive rods at #39 Starting to drill through concrete pad.

Aug 21, 1991

9:53 After drilling through ~5" of concrete, Crew at 304 now driving rods.

PID reading top of hole 15 ppm.

10:00 Collected sample from 5' BG.

Rods driven into ground hydraulically ("Geoprobe").

10:06 Rods down 21' BG. No reading on PID at top of rods.

10:12 Crew at #304 repairing a Swagelock fitting.

10:20 Crew next to road having difficulty drilling through asphalt. At location 304, fitting appears to have been repaired.

10:22 Sample collected at 21' BG.

10:25 M. Mannale and J. Cates arrive at 304 to collect sample blow files

10:30 J. Barnes returns to staging area.

8/21/91

Results from yesterday:

Sample (ug/l)	1-1DCE	t 1-2DCE	1-1DCA	C-12DCE
101 (Blank)	ND	→	→	→
102 (Blank)	ND	→	→	→
103S	44.48	.04	ND	3.59
103D	ND	ND	2.7	1.58
104S	ND	ND	ND	ND
104D	7.44	ND	3.7	ND

Sample	1,1,1-TCA	TCE	PCE
101	ND	→	→
102	ND	→	→
103S	4.14	11.08	16.57
103D	16.48	7.21	14.25
104S	.31	.68	.03
104D	213.5	223.25	11.35

J. Barnes arrives at #306 Dan & Steve just collected sample from 5' BG.

At street location (#303) Sample from 8' BG being collected at 1042 hrs.

1045-12 J. Barnes called office and relieved Ed Blackman at GM-201.

8/21/91

12- Lunch break.

1:25 Target personnel start arriving. John & Nelson start drilling through concrete at #309.

1:30 Crew at #109 drilled through 4'8" of concrete (limit of equipment). Could not drive rods - concrete thicker than 18". Moving on to next location.

Location 311 is located in center of piece of scrap metal. For most part it is paved, albeit in poor state of repair. Crew found a spot where they did not have to drill.

1:42 Sample collected at 311S (S=shallow).

1:57 Sample 311D collected.

2:00 J. Barnes back at staging area. Injection carousel for GC not working. M. Marnell in "hand" injecting samples into GC. First injection just a couple of minutes ago.

8/21/91

2:05 Spoke w/ W. Mallare:
Samples stored in labelled plastic bags at ambient temp. Some samples may be sent to a fixed based lab since he is running far behind.

2:12 Location #318 Steve & Dan setting starting to drive rods.

2:17 Sample 318-5 collected.

2:25 Sample 318-D collected.

2:28 J. Coates arrives to pick-up samples and dirty rods.

2:30 Leaking hydraulic fluid on-rig.

2:35 Finished at #318 Hole was filled w/ bentonite powder and topped off w/ asphalt. Steve tightened hydraulic joints.

2:42 Dan & Steve start driving rods at #320.

2:43 Sample 320-5 collected.

2:53 Sample 320-D collected.
No leaking hydraulic fluid noted

8/21/91

SS - J. Barnes leaves for GW-20.

SS - J. Barnes returns to staging area.

More results:

Sample 105-S

1,1,1 TCA	10.7 ug/l
TCE	1.45
PCE	33.28

Lost DD

105-D

1,1,1-TCA	14.92
TCE	2.29
PCE	42.18

106-S

1,1 DCE	6.05
C-1,2 DCE	1.51
1,1,1 TCA	1.59
~~PCE~~	3.45
PCE	4.35

106-D

1,1,1 TCA	0.22
TCE	1.22
PCE	0.12

MS Blank 106-D

ND all around.

8/21/91

3[40] John & Stan (Target) mobilize at location 315 (just N of drum area)

3[48] Crew drilled through concrete. Start driving rods. Rig is leaking hydraulic oil.

351 Sample 315-S collected.

4:05 Sample 315-D collected.

4:15 Same crew moves onto location 317. This is located on 2nd east-west trending road south of Stewart Ave. Approximately 5 locations trending from 317 north along grass between road and parking lot will be sampled.

4[22]-4[50] J Barnes at Plant 16 to make phone calls.

4[32] Sample 317-D collected (21' BG).

4[45] John & Stan move onto #319. A pan is now being used to collect leaking oil.

4[51] Sample 319-S collected (5' BG.)

5[02] Sample 319-D Deep ~21' BG

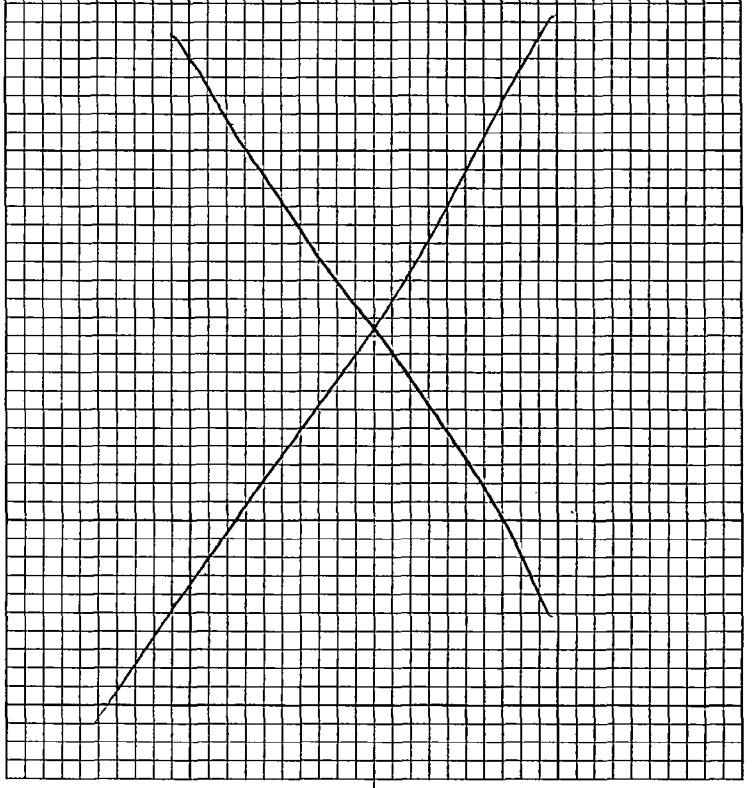
Aug 21, 1991

5:20 Sample 321-S collected (5')

5:30 Sample 321-D collected (21')

5:35 Work completed for day.

J Barnes leaves site.



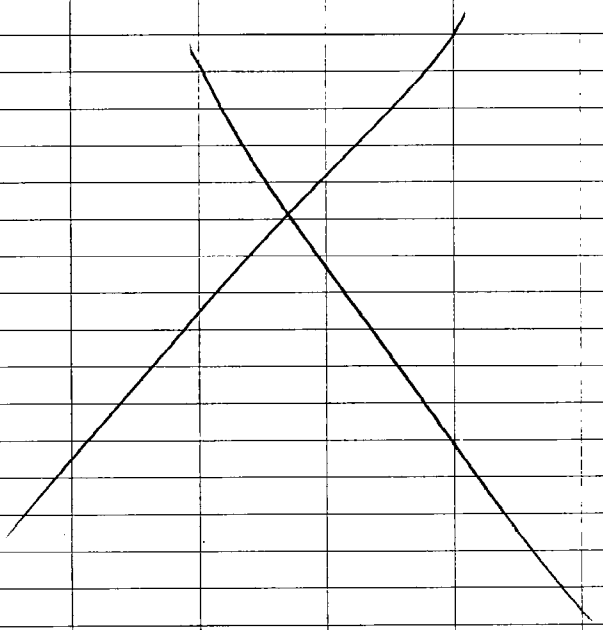
August 22, 1991

J. Barnes arrives on-site at 7:45 AM.

Target and NUS personnel not on-site yet.

8:30 Target personnel begin to arrive on-site. They then leave staging area (and site?).

9:00 J. Barnes leaves for Albany



August 26, 1991

J Barnes arrives at 12:50

Operations on-site: hydropunch / soil sampling and soil gas survey (Target)

There are 2 drill rigs in Area 1.

Drill firm: Aquifer Drilling & Testing

LIC, NY → hydropunch

Work on going at

locations: 113 North-central part of Area

115 - Center of Area 1

Loc. 113

~~Randy Fitz~~ Patterson NUS

Loc 115 David Post NUS

Loc 113

spoon 40-42' HNu ~ 5 ppm

16" Rec.

Red-orange coarse sands

8/26/91

1:05 Log 115:
Drill crew sending hydropunch down hole.
Correction - temporary wells are being used instead of hydropunch.
Well screened 39-49 BG.

1:22 Loc #115
Purging building well prior to sampling. Water is color of chocolate milk. Goal - 3 well volumes will be purged.

1:32 12 bailers of water purged. Water still muddy. Sample poured into 40 ml amber vials.
Sample collected Terry Rajha - NUS.

1:36 Drillers start pulling augers at #115.

Location 115
44-46' BG
6" Rec
Top 8" Red-brown coarse sand (fall down)
Bottom 8" Tan fine-medium sand - wet.

8/26/91

46-48' BG

2/3	Brown fine sand
2/2	trace silt
	HNu = 0
	Rec 8"

1:38 D Yost measures water at #2 1/5 BG at #115.

1:55-2:05 J Barnes moved over to Site 2
Spoke w/ K. Kilmartin NOS:
1 - Drill and decon water:
Contractors supposed to procure water offsite.
2 - Muddy water sample from Temporary well. Sample to be sent to H2M - overnight turnaround.

2:07 Setting temporary well at #113. A drum cover has been placed over hole - it will be grouted at the end of the day.

2:15 Well 113 screened from 38-48' BG.

8/26/19

Alan Margraf - HSP - NUS on-site

2:22 Crew which worked at 115 now setting-up at #103.

Hole 103
Sample 3-5' BG
Sample placed into 3 - 40 ml vials 2 amber jars ~125 ml

5/14 Rec: 19"

13/12 HNu: 0.4

Desc: coarse sand and gravel w/ pebbles. Sand white-brown in color.

2:39 At Location 113. Purged well dry. Allowing well to recover.

2:41 Soil boring cuttings drummed. Final disposition will be based on analytical results.

2:45 Back at #103 - Driller augering to 19' BG.

2:51 Crew preparing to sample 19-21' interval at #103.

8/26/91

Loc 103 — 19-21' BC — Sample placed into 3- 4 oz jars.

8/23 — Rec: 24" — HNu: 1.2

23/23 — Desc: Med-coarse brown sand, some fine sand pebbles and gravel prevalent in top 12".

300 Crew at 103 augering. They are to augur to 34 feet - and start collecting split-spoons from there on.

Crew at 113 pulling augers.

305-310 J Barnes to Area 2

Un.-Tech D.: Wing setting up a de-con pad.

3:13 Crew preparing to sample 34-36' interval at #103.

34-36' at #103

8/12 — Rec: 15" — HNu: 0.5 ppm

13/11 — Desc: Tan med-fine sand some gravel.

8/26/91

3:22 Augers down 39' BG. Crew preparing to sample 39-41' interval.

According to D. Post, well casing & screen (2" PVC) is to be steam cleaned & re-used.

Loc 103 39-41' BG

7/19 Rec: 20"
HNu: 9.6ppm
30/24 Desc: Light brown med. ~~sand~~ to fine fine sand ~2" lens of clay at ~~top of spoon~~ 1.5' down

↓
Region of highest HNu reading

---

342 Crew sampling 42-44' BG @ loc 3.

345 The other rig has been mobilized to loc 11. Drillers sampling 3-5' BG interval.

#11 3-5' Rec = 20"
7/19 HNu =
2V12 Desc = Brown to red-brown coarse sand and gravel w/pebbles,
Sample collected in 3-4oz jars and 2 125ml jars (amber)

1:26	Work started again Level D. During lunch, Kevin went and calibrated another HNu. We just tested with it and it shows no diff between zones.
1:33	Headspace 70'-72' 0.6 - 0.2 = 0.4 ppm
	↑ this sample was clay-y.
1:47	Drillers still clearing augers before spooning 80'-82'
2:00	80'-82' 10, 4, 15, 25
	18" recovery - light brown/red med sand.
	Kevin went to make phone calls and will return with HNu calibration gas to recheck HNus.
	Joe from Delta is leaving for the day.
2:20	Kevin is back & checking the HNu.
2:35	90-92' 2, 7, 7, 16
	18" recovery - light brn/gry, med to coarse sand
	Kevin took 2 jars for headspace to compare HNus.

back up again at level D and
will closely monitor.

11:44 60-62' 5, 4, 5, 10 Headspace 50-48=~~45~~ 45.2 ppm

moist, coarse, light brown sand with red staining

12:00 Augered to 70' - Drillers break for lunch.

12:30 70-72' 6, 14, 14, 14

1' recovery, some gray clay then grey fine to med grain sand

1:00 Augers to 80' - Kevin is upgrading to level C based on consistant 2 ppm difference in zones. - But

drillers want to wait to see if zone airs out upon waiting.

11:09 Kevin used a dregar tube to test for vinyl chloride in the work zone but it came up negative. He is now testing with HNu again to see if it is alright to restart.

12/16/91

J. Lister arrives @ site 7:00 a.m.

Weather 30°F Mostly Sunny
Windy

Kevin Kilmartin - NUS

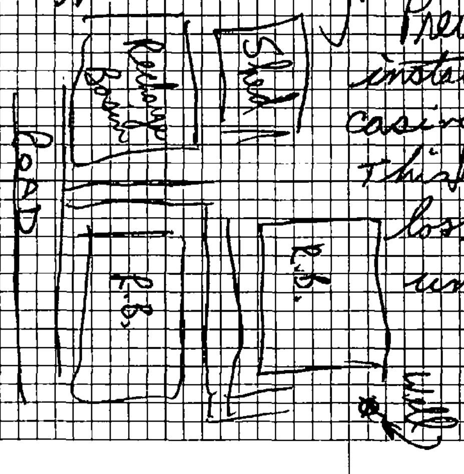
Mike & Lou - Delta Drillers

Set up with mud rig on deep well in corner of recharge basins

Failing drill rig being used for mud rotary.

Previous Friday (12/13) installed a 11" I.D. casing to GWT+/85 ft bls

This is to help minimize loss of mud in unsaturated zone.



7:15 Drillers working on establishing hook-up to hydrant

8:30 Hook-up complete, drillers back to rig

9:15 Pump on drill rig frozen (check valves) thawing to chip ice out

10:30 Pump still frozen Flatbed arrived & unloaded pallets of drilling mud & portland cement

10:50 Pump being freed up by running water through it

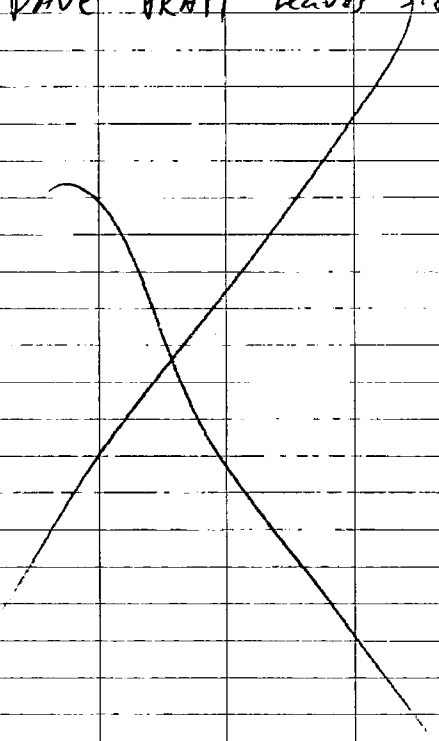
11:15 Hooking up hoses to drill rig

11:50 All hoses hooked up Bailer sent down hole & is being pulled up & down at bottom of hole

readings since they may not have headspace to base their choice for deep well screened zone on.

Driller's going to leave 160' of augers in hole.

6:45 DAVE BRAFF leaves site



headspace readings in the
zones above this. John Barnes
will/should be consulted

Monday morning

6:11 220-222 = light brn fine/med grained sand
(heave?)

6:26 Headspace #1 0.9-0.2 = 0.1
#2 12.6-1.8 = 10.8

Talking to Kevin the plan Monday
will be as follows:
At start-up - have drillers go to 270'
by the time they reach this depth
they + Kevin should (?) be able
to talk to the Navy and I
should be able to talk to John
Barnes or Sue Petrovich as to
whether they should try to grab
samples @ 230, 240, 250. I told
Kevin to expect to drill to 250
to at least take gamma

12/8/92

1:30-1:45 Spoke w/ FK Landahan and Jim Colter (US Navy) about project

12-8-92
John Barnes arrives at the temporary well location on Thomas Ave, between 9th and 10th streets. 9:55 AM

Drill Co. Aquifer Drilling & Testing
MNVS – F. Ransom

Auger bit ~ 45' BG (Ransom)

10:38 temporary well set ~ 45-55' BG
WT ~ 52' (Ransom)

10:42 ~ 5 gals purged from well.
pH = 6.5
Cond = 360 umhos/cm
Water - brown in color.

10:50 Ransom collected gw sample using 4 - 40 ml clear glass vials.
I asked him which lab is being used
He did not know - I'll ask K. Kilmartin later. J Barnes leaves site.

11:30 According to Kilmartin - lab used is Volumetrics.

11:45 I asked that all data generated be forwarded to me (request to Ransom)

NYSDEC 002058

12-2-92

2nd Butler thinks a foot of heave possibly due, moved inside bottom of augers.

NOTE 20' South of piezometer there appears to be a manhole or other opening to tank or whatever.

Dealt w/ during FS

Well Screened
51-61' BG
2" PVC
0.02 slot
#2 morie sand

Bentonite pellets to be used.
According to F. Kaser,

J Barnes leaves site 2:50 - Return to Albany

12/2/92

12[16] Drilling stopped - 5ppm [illegible] reading in breathing zone.

1225 Discussed safety concerns w/ K. Kilmartin and drillers. I recommended upgrading level of PPE - Level C.

Decision - Level C respirators. Drilling halted - drillers need respirators brought to Plant site from their home office.

1230 J Barnes leaves for GM-3D

2[20] J Barnes returns to piezometer location. Drill crew wearing resp. [illegible].

Depth of boring 61' (F. Ronan - NUS)

Crew pulling some augers and installing sand pack.

Note: F. Ronan monitoring breathing zone w/ HNu. He is not wearing a respirator. No hits on HNu. No hits since respirators were donned.

2[32] Drill crew attempting to loosen bridged sand w/ weighted tape.

December 2, 1992

10:07 After driving through the residential neighborhood east of the NYWRP site - I drove to the staging area (Site 1) where I finally found a drilling rig: Aquifer Drilling and Testing, Inc.
It appears that they arrived today. No odd to be found.
J Barnes back to GM-36D (GAC RI/FS.)

11[55] J Barnes arrives at Site 1
Drill crew drilling borehole for a piezometer to be screen 8' below - 2' above WT.
HN_3 readings 25 ppm in breathing zone. No vinyl chloride - according to Kevin Kilmartin

According to Kevin, Delta Well & Pump will mobilize tomorrow. They will install 8" test well via reverse rotary w/ water all the way to 110-115' (total depth of well)

Fred (Stone & Webster) continuously monitoring breathing zone w/ HN_3.

2/12/92

14:10 Sampled #25 via bailer.

#RA0-0212-B13603

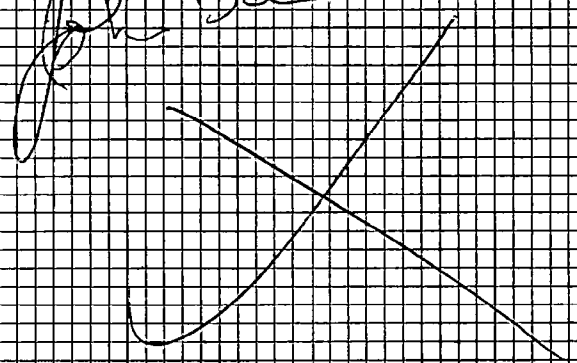
2 40ml vials

1 1-l bottle (plastic) - HNO3 was added after sample collected.

2:30 - J Barnes leaves site

3:00 - J Barnes relinquishes samples to Federal Express in Wickville.

A.C. Bill # 661294782 1



2/12/92

13^{05} JBarnes and NUS personnel arrived #29D-, NUS de-conning sampling equipment.

De-con procedure -
Wash w/ Alconox soln.
Rinse w/ distilled H_2O

13^{25} Collected sample at 29D via bailer:

RA491-0212-B13601

2 - 40 ml vials
1 - 1 litre Plastic bottle
I added 1:1 HNO3.

Cond 140 µS/cm
T 12.1 C
pH 7.85

13^{40} NUS deconning bailer

13^{45} NUS personnel & I arrive at MW-25D.
This well was purged yesterday afternoon per Kilmartin

2/12/92

1130 Depth to water 56' BG

1141 Pump set @ ≈ 80' BG.
Purging begins

1203 Purging completed.
Pump rate 2 gpm.

1225 Sampled 8D (Note - I wrote down wrong time on sample bottles (11:25). For consistency I will write 1125 on all paperwork.)
3 bottles - 2-40 ml VOA
1-1 liter bottle (double a little HNO_3).

Sample # RA091-0212-B13602
Note - bottle (1-liter) - plastic.

1247 Temp with 16.3°C
pH 10.06
Cond 329 µS/cm
Sampling via S.S. bailer
4" Dia

February 12, 1992

John Barnes arrives on-site at 10:10 - Sign in, etc
Weather - clear - cold
T = 19°F

10[40] Finally find NUS crew (K. Kilmartin, R. Patarcity) at #29D. They just finished purging well w/ Stainless steel submersible pump (Grundfos).

Total purged ~ 350 gallons (pumped to tanker - Delta).

Well screened 210-220 BG
Pump at 75' BG
Static 40' BG
- per Kilmartin

10[50] JBarnes to Plant 16 to make phone calls. Delta Rig leaves #29 (heading to MW-8D.

11[20] JBarnes arrives at 8D. NUS personnel arriving at the same time. Delta rig already here.

5:45 Pulling air line out of hole.
6:00 All air line removed
6:15 5 lengths of 15' drill rod removed
6:30 Lead drill rod removed.
7:00 Left site

James B. [illegible]

NYSDEC 002066

3:10 Stopped drilling and are working on mud pump again to unthaw it

3:25 Mud pump thawed out Started high volume wash

3:45 Stopped drilling pulling rod up

3:55 Adding another 10' of drill rod

4:10 Down to 185' BGS need to be at 198' BGS

4:30 Low brought over mixer for bentonite

4:45 Unloading 4" PVC well casing.

5:00 Drilling @ 193' BGS

5:30 Drilled to 198.5' BGS

1:45 High volume wash of hole has started

2:00 Water trailer hauled off to dump mud

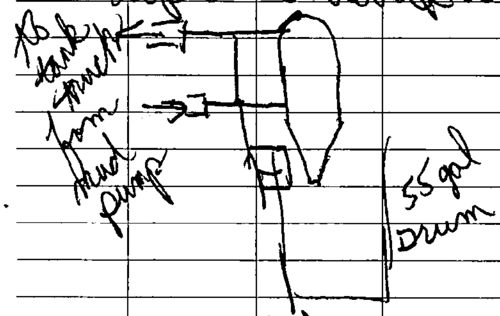
2:20 Have pulled one rod up and separated from rest in hole. Trying to separate air line where rods broken however they seem to be seized. Using acetylene torch to ~~try and loosen up the rest~~ ~~of~~ cut holder for pipes.

2:40 Have added on another 10' piece of drill rod

2:45 Have started high volume wash

3:00 Started drilling last 10' of well

11:20 Mud line from pump hooked up to a device as seen below



11:45 Dave Yost of NES arrived & started helping Kevin put plastic liner in dumpster

12:15 Left for lunch & get gas in truck

12:45 Returned to site

1:00 Started drilling ~~with~~ washing hole ~~water~~ out with water. Excess mud being pumped into tank truck

1:30 Tractor arrived to remove water tank trailer & dump mud into dumpster

9:30 Dumpster arrived & dropped off container at staging area

9:45 All 5 drill rods, removed the day before, have now been reinstalled. Inserting air pipes down rods.

10:15 Thawing out mud pump with water.

10:40 Mud pump thawed out and started up to circulate mud in through

11:00 Line returned with 2 pipe fitter for air line

11:15 Line hooked up to pump mud from through into water tank truck

8:30 Ready to start hooking drilling rods up again.

8:45 First rod replaced into hole

9:10 Air line being hooked up to top of water drilling leader. 20' air pipe installed into leader. Kevin has left site to await a truck with a roll-off dumpster.

9:20 Kevin returned. Hydrofracked.

9:25 Spoke to Stanley & Kevin about air line. Stanley indicated air was to be used for lift during reverse water drilling. I indicated that the air line should have filters on it. Kevin agreed Stanley said he'd get one.

Comer B. Fish 12/18/91

Arrived 7:00 a.m.

Weather Clear, Temp ~30°F

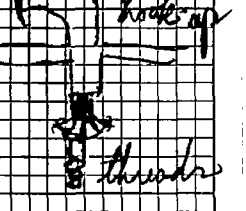
Kevin Kilmartin - URS

Mike, Lou, Stanley, Bob - Delta

Speed to complete hole + install well today. To use reverse water rotary to complete hole. Show screened interval.

7:30 Drillers moved mud drilling head off of rig

7:45 Installing water drilling head on rig



to be sure all cuttings removed from hole

4:45 Adding more bentonite to mud.

5:15 Starting to pull rods out of hole

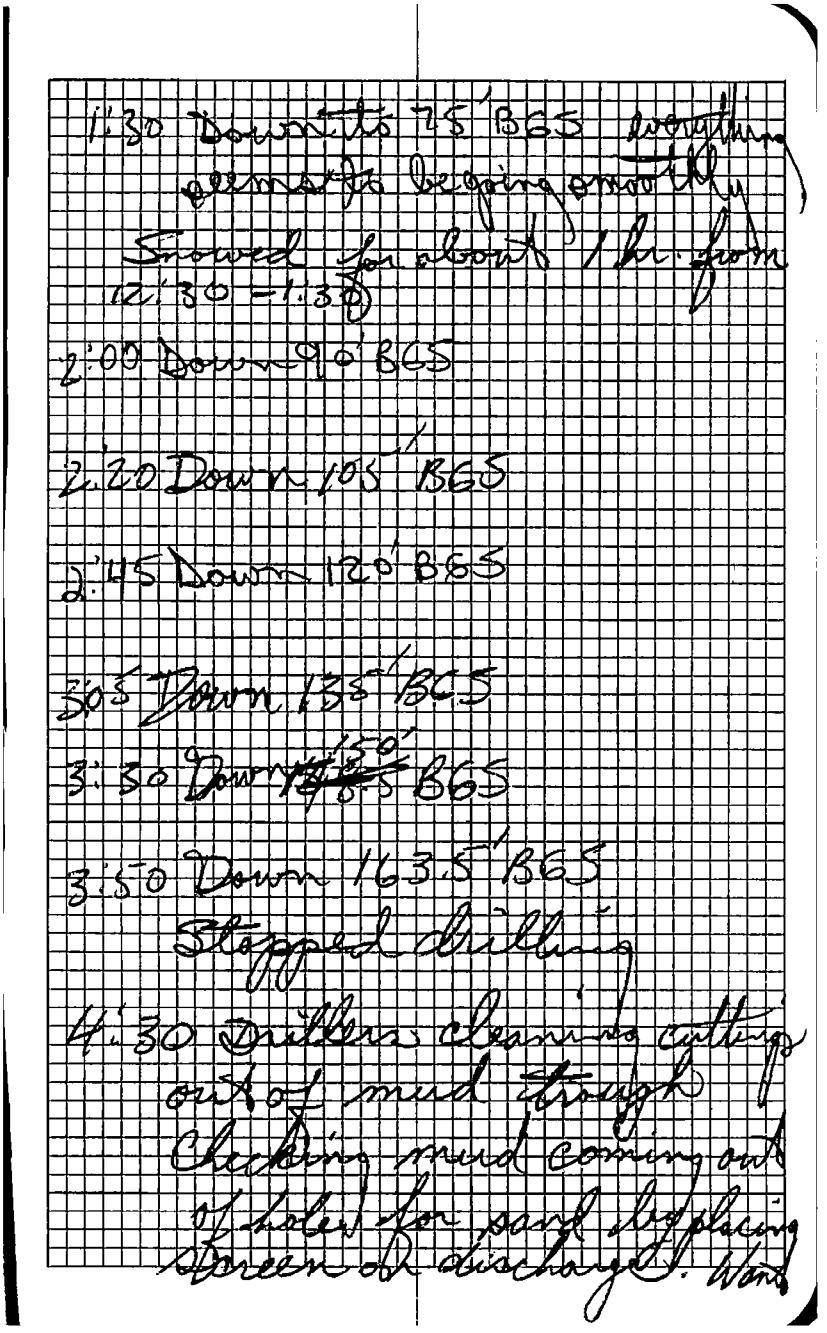
5:25 First rod out & disconnected

5:40 Fifth rod removed, will leave the rest in the hole overnight

5:50 Blew mud lines out with compressed air
Drained mud pump

6:00 Left site

James B. Foster


1:30 Down to 75' BGS everything
seemed to be going smooth
Showed for about 1 hr. from
12:30 - 1:30
2:00 Down 90' BGS
2:20 Down 105' BGS
2:45 Down 120' BGS
3:05 Down 135' BGS
3:30 Down ~~150'~~ 148.5' BGS
3:50 Down 163.5' BGS
Stopped drilling
4:30 Drillers cleaning cuttings
out of mud trough
Checking mud coming out
of hole for sand & placing
screen as discharge is clear

left to get refil

9:30 Low returns

Mud trough thawed out by adding more water & starting mud pump to circulate.

Saw letter from Polymer Drilling to Delta predicating mud is 100% Wyoming bentonite

10:15 All lines thawed & hooked up

Drillers on coffee break.

10:45 Mud finally pumped into drill rods, & everything seems to be working OK.

11:00 Adding more ~~mud~~ bentonite to mud mix.

11:15 Two bags of bentonite added so far today to mud

12:00 Rig finally started drilling

12:15 Broke for lunch

12:45 Lunch over

12/17/91

James Lister

Arrived at site 7:00 a.m.

Weather Overcast high teens

Kevin Langdon UPCS, Mike Lord, Stanley Bob Dutt

Mud trough frozen

Drillers pulling mud pump back together. Several lines need to be replaced after being removed & thawed out previous night.

Drillers clean yesterdays spray up of lines due to previous job didn't drain all mud lines.

8:30 One line still frozen. Everything else seems thawed out.

Torch keeps going out.

8:50 Ran out of acetylene gas, Low

3:30 Mud pump leaking
3:35 Determined that pipeline to drill rods has frozen up
3:45 Using acetylene torch to try and heat up mudline pipe.
4:05 Hole pipe frozen solid Pipe will have to be removed and thawed out
4:45 Taking pump apart
4:50 One piece of pipe removed
5:00 Left site

James B Stahl

12:15 Broke for lunch

12:45 Returned from lunch, Drill crew just coming off lunch

12:50 Started washing hole out by adding water down hole & bailing

1:10 Finished washing out hole Started to mix drilling mud by recirculating into circulation line ~~Start~~ Hbags or pallets to

2:10 Used Six (6) bags of drilling mud and is ready

2:15 Getting ready to hook up drill stem

2:45 Lead drill rod lowered into hole.

3:05 Problems with alignment of drill rods (3 rods (45') in hole)

Drillers turned off rig to oil some parts.

2:41 Drillers now augering to 100'

3:18 I left to make phone calls.

100'-102' → entire spoon clay.

Are now augering to 110.

327 - Headspace for 90-92

1st HNu → 0.4 - 0.2 = 0.2 ppm

2nd HNu → 820 - 4 = 816 ppm ← ?

This HNu has been used all day & therefore HNu alerts to MS point & should be treated as suspect.

3:55 110'-112' 20, 29, 25, 26

18" - mixture of clay lenses & red/brn sand

Augering to 120'

4:09 Headspace 110-12 - 1st HNu 0.4 - 0.2 = 0.2 ppm
2nd HNu 2000 ppm

4:20 120'-122' 4, 21, 23, 25

4:28	120-122	2nd recovery
		120.5-122 clayey silt with med grained sand mixed in. - alternating red + white bands.
		120-120.5 - red, light brown sand
4:50	120-122	head space
		1ST 0.4-0.2 ppm
		2nd 130 ppm
5:00	130-132	7, 21, 28, 33
5:10	18" of	red & wht. banded clay.
5:28	130-132	headspace
		1ST HNu 2.3-2.3
		2nd HNu 0.4-0.2 = 0.2 ppm
5:51	140-142	
		18" red/wht silty sand.
		headspace 0.2 ↔ 260 ppm #1 #2
6:39	150-152	
	full recovery	1/2 light brn fine sand
		1/2 yellow " "
		Headspace #1 0.1 ↔ #2 8.6 ppm
6:48	Augers remain at 150' for the night.	
	Now cleaning up site + getting	
	ready to leave.	
7:00	Leave site	

11/25/91 OAUEPRAM

Weather - overcast, 50°

7:45 Arrive Bldg 16 to meet Kevin (NUS) Joe Conrad (OFCTA) and our Navy escort - Ed Ambrose.

8:05 Arrive HW-29 pilot hole.

No developing today - Just work on getting this pilot hole to 250'. Joe will be head driller & Conrad assisting.

8:20 HPMT are calibrated - Kevin still wants to use both - #1 will be the one I think is good, #2 will be the one from yesterday that I do not trust. - However, no rain forecasted for today so either may work fine.

8:35 Drilling commences.

Augering to 160'

8:45	Augers @ 160' HNu #1 detects nothing above 0.25 ppm background in work-zone.
8:55	6' of heave moved up into the augers over the night - Drillers are bailing it now
9:03	Sending spoon down hole.
9:20	160-162 14, 21, 27, 42
9:27	Spoon out of hole
	1st foot - heave 2nd foot - grey, very silty
9:43	Augers to 170' → 3' of heave being bailed now.
	HNu ⇒ nothing above background.
9:56	160 - headspace 0.8 - 0.6 = 0.2 ppm
	170-172 - spoon halfway down hole
9:58	170'-172 5, 14, 16, 21
10:07	Spoon out of hole
	1' heave 1 wht/grey silty fine sand w/ red bands

10:30 Augered to 180' — now have
12' of heave in auger to clay

10:50 Stanly from Delta arrives (why?)
170-172 Headspace 0.5-0.6 - 0.2 ppm

10:56 Spoon in hole.

11:05 Spoon to bottom of hole, begin hammering

11:09 180-182 5, 8, 24, 61
Now guillons spoon.

11:17 Spoon out 180'-182'
18" heave
3" red fine sand
3" yellow silty sand

11:46 190-192 (7, 13, 19, 24)

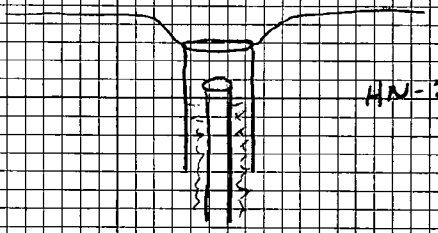
11:47 Headspace for 180-182 0.5-0.4 = 0.1

11:53 190-192
6" sand silty sand

Rods HWA in overhead ⇒ nothing

12:19	190-192	HNU - headspace	0.4-0.3 = 0.1 ppm	
12:27	200-202'	9, 10, 32, 36		
12:35	200-202			
	1' recovery - grey silty fine sand with 1 yellow band 1 redish band			
12:45	Set to Auger to 210 - first Lunch.			
1:30	Lunch over			
1:52	Headspace 200-202'			
	#1 0.4-0.3 = 0.1 ppm			
	#2 13.8 - 1.4 = 12.4 ppm (?)			
	Augers @ 210, now lowering spoon.			
2:02	210-212'	7, 7, 9, 30		
2:14	210-212	1" recovery grey/lt brn silty fine sand. all the rest → heave.		
	Headspace #1 0.2 / #2 @3.4 ppm			
2:47	Now lowering to 220 the spoons.			
3:00	Rope broke at cathead when trying to retrieve spoon. Drillers will now put another rope through and try again to retrieve spoon			

1:21 Went to HN-24, with Kevin. To see whether recent construction in the area had really pushed or broke the casing – NO, it's fine. If (doubtful) anything was pushed down, it would be the protective casing not the well casing itself:



HN-24S

Kevin is sure it was like it was before any work.

HN-29 – still having difficulty retrieving spoon – definitely last sample of the day.

3:57 HN-29 still trying.

4:30 Have tried several method and still no success. Rig is off and

we are discussing posibilities.

5:09 Have removed 15' of both auger and sampling rod - as they both came up together. Now leaving 205' of augers with 2' of sampling rod protruding at top (total length 207') Are now removing another 10' section of both - then I may have them try to work it free with the hammer again.

5:49 Did not need hammer - broke free - got 5' of rod out and tried to pull with normal cinch but is still resisting. Now trying hammer

5:57 Completely free and rods easily pulled now.

Kevin posed the question as to whether the last 3 samples (230', 240', 250') are worth the effort on monday to try again in this pilot hole - I seem to agree that the planned down hole gamma reading may be enough based on the apparant lack of any significant

CURVE TABLES

Published by KEUFFEL & ESSER CO.

HOW TO USE CURVE TABLES

Table I. contains Tangents and Externals to a 1° curve. Tan. and Ext. to any other radius may be found nearly enough, by dividing the Tan. or Ext. opposite the given Central Angle by the given degree of curve.

To find Deg. of Curve, having the Central Angle and Tangent: Divide Tan. opposite the given Central Angle by the given Tangent.

To find Deg. of Curve, having the Central Angle and External: Divide Ext. opposite the given Central Angle by the given External.

To find Nat. Tan. and Nat. Ex. Sec. for any angle by Table I.: Tan. or Ext. of twice the given angle divided by the radius of a 1° curve will be the Nat. Tan. or Nat. Ex. Sec.

EXAMPLE

Wanted a Curve with an Ext. of about 12 ft. Angle of Intersection or I. P. = 23° 20′ to the R. at Station 542+72.

Ext. in Tab. I opposite 23° 20′ = 120.87
120.87 ÷ 12 = 10.07. Say a 10° Curve.

Tan. in Tab. I opp. 23° 20′ = 1183.1
1183.1 ÷ 10 = 118.31.

Correction for A. 23° 20′ for a 10° Cur. = 0.16
118.31 + 0.16 = 118.47 = corrected Tangent.

(If corrected Ext. is required find in same way)
Ang. 23° 20′ = 23.33° ÷ 10 = 2.3333 = L. C.

2° 19½′ = def. for sta.	542	I. P. = sta.	542+72
4° 49½′ = " " "	+50	Tan. =	1 .18.47
7° 19½′ = " " "	543	B. C. = sta.	541+53.53
9° 49½′ = " " "	+50	L. C. =	2 .33.33
11° 40′ = " " "	543+	E. C. = Sta.	543+86.86
	86.86		

100 − 53.53 = 46.47 × 3′ (def. for 1 ft. of 10° Cur.) = 139.41′ =
2° 19½′ = def. for sta. 542.

Def. for 50 ft. = 2° 30′ for a 10° Curve.
Def. for 36.86 ft. = 1° 50½′ for a 10° Curve.

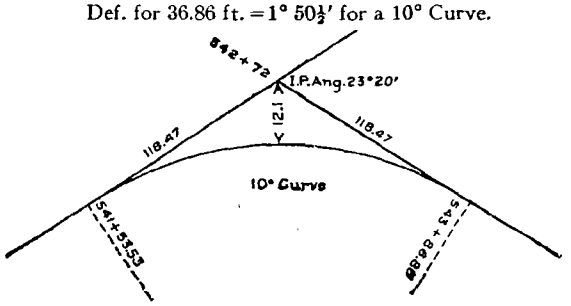


Table I. — Tangents and Externals to a 1° Curve. Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
1°	50.00	.22	8°	400.66	13.99	15°	754.32	49.44
10′	58.34	.30	10′	409.03	14.58	10′	762.80	50.55
20	66.67	.39	20	417.41	15.18	20	771.29	51.68
30	75.01	.49	30	425.79	15.80	30	779.77	52.82
40	83.34	.61	40	434.17	16.43	40	788.26	53.97
50	91.68	.73	50	442.55	17.07	50	796.75	55.13
2	100.01	.87	9	450.93	17.72	16	805.25	56.31
10	108.35	1.02	10	459.32	18.38	10	813.75	57.50
20	116.68	1.19	20	467.71	19.06	20	822.25	58.70
30	125.02	1.36	30	476.10	19.75	30	830.76	59.91
40	133.36	1.55	40	484.49	20.45	40	839.27	61.14
50	141.70	1.75	50	492.88	21.16	50	847.78	62.38
3	150.04	1.96	10	501.28	21.89	17	856.30	63.63
10	158.38	2.19	10	509.68	22.62	10	864.82	64.90
20	166.72	2.43	20	518.08	23.38	20	873.35	66.18
30	175.06	2.67	30	526.48	24.14	30	881.88	67.47
40	183.40	2.93	40	534.89	24.91	40	890.41	68.77
50	191.74	3.21	50	543.29	25.70	50	898.95	70.09
4	200.08	3.49	11	551.70	26.50	18	907.49	71.42
10	208.43	3.79	10	560.11	27.31	10	916.03	72.76
20	216.77	4.10	20	568.53	28.14	20	924.58	74.12
30	225.12	4.42	30	576.95	28.97	30	933.13	75.49
40	233.47	4.76	40	585.36	29.82	40	941.69	76.86
50	241.81	5.10	50	593.79	30.68	50	950.25	78.26
5	250.16	5.46	12	602.21	31.56	19	958.81	79.67
10	258.51	5.83	10	610.64	32.45	10	967.38	81.09
20	266.86	6.21	20	619.07	33.35	20	975.96	82.53
30	275.21	6.61	30	627.50	34.26	30	984.53	83.97
40	283.57	7.01	40	635.93	35.18	40	993.12	85.43
50	291.92	7.43	50	644.37	36.12	50	1001.7	86.90
6	300.28	7.86	13	652.81	37.07	20	1010.3	88.39
10	308.64	8.31	10	661.25	38.03	10	1018.9	89.89
20	316.99	8.76	20	669.70	39.01	20	1027.5	91.40
30	325.35	9.23	30	678.15	39.99	30	1036.1	92.92
40	333.71	9.71	40	686.60	40.99	40	1044.7	94.46
50	342.08	10.20	50	695.06	42.00	50	1053.3	96.01
7	350.44	10.71	14	703.51	43.03	21	1061.9	97.57
10	358.81	11.22	10	711.97	44.07	10	1070.6	99.16
20	367.17	11.75	20	720.44	45.12	20	1079.2	100.75
30	375.54	12.29	30	728.90	46.18	30	1087.8	102.35
40	383.91	12.85	40	737.37	47.25	40	1096.4	103.97
50	392.28	13.41	50	745.85	48.34	50	1105.1	105.60

Corrections to be Added (T = Tangent. E = External.)

Int. Angle	Curve 5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
5°	T=.02	.03	.05	.06	.08	.10	.11	.13	.15	.16	.18	.20	.21	.23
	E=.000	.000	.001	.001	.002	.002	.002	.003	.003	.004	.004	.004	.005	.005
10°	T=.03	.06	.09	.13	.16	.19	.22	.25	.28	.31	.34	.38	.42	.46
	E=.001	.003	.004	.006	.007	.008	.009	.011	.012	.014	.015	.017	.018	.020
15°	T=.04	.10	.14	.19	.24	.29	.34	.39	.45	.51	.53	.58	.63	.68
	E=.003	.007	.010	.014	.018	.023	.027	.029	.032	.035	.039	.043	.047	.051
20°	T=.06	.13	.19	.26	.32	.39	.45	.51	.58	.65	.72	.79	.84	.90
	E=.006	.011	.017	.022	.028	.034	.038	.045	.051	.057	.063	.070	.076	.083
25°	T=.08	.16	.24	.33	.40	.49	.58	.67	.75	.83	.90	.99	1.06	1.14
	E=.009	.018	.027	.036	.046	.056	.065	.074	.083	.093	.106	.120	.127	.135

Table I. — Tangents and Externals to a 1° Curve.

Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
22°	1113.7	107.24	**29°**	1481.8	188.51	**36°**	1861.7	294.9
10′	1122.4	108.90	10′	1490.7	190.74	10′	1870.9	297.7
20	1131.0	110.57	20	1499.6	192.99	20	1880.1	300.6
30	1139.7	112.25	30	1508.5	195.25	30	1889.4	303.5
40	1148.4	113.95	40	1517.4	197.53	40	1898.6	306.4
50	1157.0	115.66	50	1526.3	199.82	50	1907.9	309.3
23	1165.7	117.38	**30**	1535.3	202.12	**37**	1917.1	312.2
10	1174.4	119.12	10	1544.2	204.44	10	1926.4	315.2
20	1183.1	120.87	20	1553.1	206.77	20	1935.7	318.1
30	1191.8	122.63	30	1562.1	209.12	30	1945.0	321.1
40	1200.5	124.41	40	1571.0	211.48	40	1954.3	324.1
50	1209.2	126.20	50	1580.0	213.86	50	1963.6	327.1
24	1217.9	128.00	**31**	1589.0	216.3	**38**	1972.9	330.2
10	1226.6	129.82	10	1598.0	218.7	10	1982.2	333.2
20	1235.3	131.65	20	1606.9	221.1	20	1991.5	336.3
30	1244.0	133.50	30	1615.9	223.5	30	2000.9	339.3
40	1252.8	135.35	40	1624.9	226.0	40	2010.2	342.4
50	1261.5	137.23	50	1633.9	228.4	50	2019.6	345.5
25	1270.2	139.11	**32**	1643.0	230.9	**39**	2029.0	348.6
10	1279.0	141.01	10	1652.0	233.4	10	2038.4	351.8
20	1287.7	142.93	20	1661.0	235.9	20	2047.8	354.9
30	1296.5	144.85	30	1670.0	238.4	30	2057.2	358.1
40	1305.3	146.79	40	1679.1	241.0	40	2066.6	361.3
50	1314.0	148.75	50	1688.1	243.5	50	2076.0	364.5
26	1322.8	150.71	**33**	1697.2	246.1	**40**	2085.4	367.7
10	1331.6	152.69	10	1706.3	248.7	10	2094.9	371.0
20	1340.4	154.69	20	1715.3	251.3	20	2104.3	374.2
30	1349.2	156.70	30	1724.4	253.9	30	2113.8	377.5
40	1358.0	158.72	40	1733.5	256.5	40	2123.3	380.8
50	1366.8	160.76	50	1742.6	259.1	50	2132.7	384.1
27	1375.6	162.81	**34**	1751.7	261.8	**41**	2142.2	387.4
10	1384.4	164.86	10	1760.8	264.5	10	2151.7	390.7
20	1393.2	166.95	20	1770.0	267.2	20	2161.2	394.1
30	1402.0	169.04	30	1779.1	269.9	30	2170.8	397.4
40	1410.9	171.15	40	1788.2	272.6	40	2180.3	400.8
50	1419.7	173.27	50	1797.4	275.3	50	2189 9	404.2
28	1428.6	175.41	**35**	1806.6	278.1	**42**	2199.4	407.6
10	1437.4	177.55	10	1815.7	280.8	10	2209.0	411.1
20	1446.3	179.72	20	1824.9	283.6	20	2218.6	414.5
30	1455.1	181.89	30	1834.1	286.4	30	2228.1	418.0
40	1464.0	184.08	40	1843.3	289.2	40	2237.7	421.4
50	1472.9	186.29	50	1852.5	292.0	50	2247.3	425.0

Corrections to be Added (T = Tangent. E = External.)

Int. Angle	Curve 5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
20°	T=.06	.13	.19	.26	.32	.39	.45	.51	.58	.65	.72	.79	.84	.90
	E=.006	.011	.017	.022	.028	.034	.038	.045	.051	.057	.063	.070	.076	.083
25°	T=.08	.16	.24	.33	.40	.49	.58	.67	.75	.83	.90	.99	1.06	1.14
	E=.009	.018	.027	.036	.046	.056	.065	.074	.083	.093	.106	.120	.127	.135
30°	T=.10	.19	.29	.39	.49	.59	.69	.79	.89	.99	1.09	1.20	1.29	1.39
	E=.013	.025	.038	.051	.065	.078	.090	.103	.116	.129	.149	.170	.179	.188
35°	T=.11	.22	.34	.47	.58	.69	.80	.93	1.05	1.17	1.29	1.42	1.54	1.66
	E=.018	.035	.054	.072	.086	.109	.131	.153	.175	.197	.213	.230	.247	.264
40°	T=.13	.26	.40	.53	.67	.80	.93	1.06	1.20	1.34	1.49	1.64	1.79	1.94
	E=.023	.046	.070	.093	.117	.141	.172	.203	.234	.265	.277	.290	.315	.341
45°	T=.15	.30	.44	.60	.76	.91	1.06	1.21	1.37	1.52	1.70	1.87	2.04	2.21
	E=.030	.060	.093	.119	.153	.184	.216	.254	.289	.325	.351	.378	.411	.445

TABLE I. — Tangents and Externals to a 1° Curve. Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
43°	2257.0	428.5	**50°**	2671.8	592.3	**57°**	3110.9	790.1
10′	2266.6	432.0	10′	2681.9	596.6	10′	3121.7	795.2
20	2276.2	435.6	20	2692.1	600.9	20	3132.6	800.4
30	2285.9	439.2	30	2702.3	605.3	30	3143.4	805.6
40	2295.6	442.8	40	2712.5	609.6	40	3154.2	810.9
50	2305.2	446.4	50	2722.7	614.0	50	3165.1	816.1
44	2314.9	450.0	**51**	2732.9	618.4	**58**	3176.0	821.4
10	2324.6	453.6	10	2743.1	622.8	10	3186.9	826.7
20	2334.3	457.3	20	2753.4	627.2	20	3197.8	832.0
30	2344.1	461.0	30	2763.7	631.7	30	3208.8	837.3
40	2353.8	464.6	40	2773.9	636.2	40	3219.7	842.7
50	2363.5	468.4	50	2784.2	640.7	50	3230.7	848.1
45	2373.3	472.1	**52**	2794.5	645.2	**59**	3241.7	853.5
10	2383.1	475.8	10	2804.9	649.7	10	3252.7	858.9
20	2392.8	479.6	20	2815.2	654.3	20	3263.7	864.3
30	2402.6	483.4	30	2825.6	658.8	30	3274.8	869.8
40	2412.4	487.2	40	2835.9	663.4	40	3285.8	875.3
50	2422.3	491.0	50	2846.3	668.0	50	3296.9	880.8
46	2432.1	494.8	**53**	2856.7	672.7	**60**	3308.0	886.4
10	2441.9	498.7	10	2867.1	677.3	10	3319.1	892.0
20	2451.8	502.5	20	2877.5	682.0	20	3330.3	897.5
30	2461.7	506.4	30	2888.0	686.7	30	3341.4	903.2
40	2471.5	510.3	40	2898.4	691.4	40	3352.6	908.8
50	2481.4	514.3	50	2908.9	696.1	50	3363.8	914.5
47	2491.3	518.2	**54**	2919.4	700.9	**61**	3375.0	920.2
10	2501.2	522.2	10	2929.9	705.7	10	3386.3	925.9
20	2511.2	526.1	20	2940.4	710.5	20	3397.5	931.6
30	2521.1	530.1	30	2951.0	715.3	30	3408.8	937.3
40	2531.1	534.2	40	2961.5	720.1	40	3420.1	943.1
50	2541.0	538.2	50	2972.1	725.0	50	3431.4	948.9
48	2551.0	542.2	**55**	2982.7	729.9	**62**	3442.7	954.8
10	2561.0	546.3	10	2993.3	734.8	10	3454.1	960.6
20	2571.0	550.4	20	3003.9	739.7	20	3465.4	966.5
30	2581.0	554.5	30	3014.5	744.6	30	3476.8	972.4
40	2591.0	558.6	40	3025.2	749.6	40	3488.3	978.3
50	2601.1	562.8	50	3035.8	754.6	50	3499.7	984.3
49	2611.2	566.9	**56**	3046.5	759.6	**63**	3511.1	990.2
10	2621.2	571.1	10	3057.2	764.6	10	3522.6	996.2
20	2631.3	575.3	20	3067.9	769.7	20	3534.1	1002.3
30	2641.4	579.5	30	3078.7	774.7	30	3545.6	1008.3
40	2651.5	583.8	40	3089.4	779.8	40	3557.2	1014.4
50	2661.6	588.0	50	3100.2	784.9	50	3568.7	1020.5

Corrections to be Added (T = Tangent. E = External.)

Int. Angle	Curve 5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
40°	T=.13	.26	.40	.53	.67	.80	.93	.106	1.20	1.34	1.49	1.64	1.79	1.94
	E=.023	.046	.070	.093	.117	.141	.172	.203	.234	.265	.277	.290	.315	.341
45°	T=.15	.30	.44	.60	.76	.91	1.06	1.21	1.37	1.52	1.70	1.87	2.04	2.21
	E=.030	.060	.093	.119	.153	.184	.216	.254	.289	.325	.351	.378	.411	.445
50°	T=.17	.34	.51	.68	.85	1.02	1.19	1.36	1.54	1.72	1.91	2.10	2.29	2.48
	E=.037	.075	.116	.151	.189	.227	.266	.305	.345	.384	.425	.467	.508	.550
55°	T=.19	.38	.57	.76	.95	1.14	1.32	1.52	1.72	1.92	2.14	2.35	2.56	2.77
	E=.046	.093	.142	.188	.236	.283	.332	3.81	.420	.479	.530	.582	.641	.700
60°	T=.21	.42	.63	.84	1.05	1.27	1.49	1.71	1.94	2.17	2.38	2.60	2.83	3.07
	E=.056	.112	.168	.225	.283	.340	.398	.457	.516	.575	.636	.697	.774	.851
65°	T=.23	.46	.69	.93	1.16	1.40	1.64	1.88	2.13	2.38	2.63	2.88	3.13	3.39
	E=.067	.135	.204	.273	.343	.412	.483	.554	.625	.697	.711	.845	.922	1.01

TABLE I. — Tangents and Externals to a 1° Curve.
Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
64°	3580.3	1026.6	71°	4086.9	1308.2	78°	4639.8	1643.0
10′	3591.9	1032.8	10′	4099.5	1315.6	10′	4653.6	1651.7
20	3603.5	1039.0	20	4112.1	1322.9	20	4667.4	1660.5
30	3615.1	1045.2	30	4124.8	1330.3	30	4681.3	1669.2
40	3626.8	1051.4	40	4137.4	1337.7	40	4695.2	1678.1
50	3638.5	1057.7	50	4150.1	1345.1	50	4709.2	1686.9
65	3650.2	1063.9	72	4162.8	1352.6	79	4723.2	1695.8
10	3661.9	1070.2	10	4175.6	1360.1	10	4737.2	1704.7
20	3673.7	1076.6	20	4188.5	1367.6	20	4751.2	1713.7
30	3685.4	1082.9	30	4201.2	1375.2	30	4765.3	1722.7
40	3697.2	1089.3	40	4214.0	1382.8	40	4779.4	1731.7
50	3709.0	1095.7	50	4226.8	1390.4	50	4793.6	1740.8
66	3720.9	1102.2	73	4239.7	1398.0	80	4807.7	1749.9
10	3732.7	1108.6	10	4252.6	1405.7	10	4822.0	1759.0
20	3744.6	1115.1	20	4265.6	1413.5	20	4836.2	1768.2
30	3756.5	1121.7	30	4278.5	1421.2	30	4850.5	1777.4
40	3768.5	1128.2	40	4291.5	1429.0	40	4864.8	1786.7
50	3780.4	1134.8	50	4304.6	1436.8	50	4879.2	1796.0
67	3792.4	1141.4	74	4317.6	1444.6	81	4893.6	1805.3
10	3804.4	1148.0	10	4330.7	1452.5	10	4908.0	1814.7
20	3816.4	1154.7	20	4343.8	1460.4	20	4922.5	1824.1
30	3828.4	1161.3	30	4356.9	1468.4	30	4937.0	1833.6
40	3840.5	1168.1	40	4370.1	1476.4	40	4951.5	1843.1
50	3852.6	1174.8	50	4383.3	1484.4	50	4966.1	1852.6
68	3864.7	1181.6	75	4396.5	1492.4	82	4980.7	1862.2
10	3876.8	1188.4	10	4409.8	1500.5	10	4995.4	1871.8
20	3889.0	1195.2	20	4423.1	1508.6	20	5010.0	1881.5
30	3901.2	1202.0	30	4436.4	1516.7	30	5024.8	1891.2
40	3913.4	1208.9	40	4449.7	1524.9	40	5039.5	1900.9
50	3925.6	1215.8	50	4463.1	1533.1	50	5054.3	1910.7
69	3937.9	1222.7	76	4476.5	1541.4	83	5069.2	1920.5
10	3950.2	1229.7	10	4489.9	1549.7	10	5084.0	1930.4
20	3962.5	1236.7	20	4503.4	1558.0	20	5099.0	1940.3
30	3974.8	1243.7	30	4516.9	1566.3	30	5113.9	1950.3
40	3987.2	1250.8	40	4530.4	1574.7	40	5128.9	1960.2
50	3999.5	1257.9	50	4544.0	1583.1	50	5143.9	1970.3
70	4011.9	1265.0	77	4557.6	1591.6	84	5159.0	1980.4
10	4024.4	1272.1	10	4571.2	1600.1	10	5174.1	1990.5
20	4036.8	1279.3	20	4584.8	1608.6	20	5189.3	2000.6
30	4049.3	1286.5	30	4598.5	1617.1	30	5204.4	2010.8
40	4061.8	1293.6	40	4612.2	1625.7	40	5219.7	2021.1
50	4074.4	1300.9	50	4626.0	1634.4	50	5234.9	2031.4

Corrections to be Added (T = Tangent. E = External.)

Int. Angle	Curve 5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
60°	T=.21	.42	.63	.84	1.05	1.27	1.49	1.71	1.94	2.17	2.38	2.60	2.83	3.07
	E=.056	.112	.168	.225	.283	.340	.398	.457	.516	.575	.636	.697	.774	.851
65°	T=.23	.46	.69	.93	1.16	1.40	1.64	1.88	2.13	2.38	2.63	2.88	3.13	3.39
	E=.067	.135	.204	.273	.343	.412	.483	.554	.625	.697	.711	.845	.922	1.01
70°	T=.25	.51	.76	1.02	1.28	1.54	1.80	2.06	2.33	2.60	2.88	3.16	3.44	3.72
	E=.080	.159	.240	.321	.403	.485	.568	.652	.735	.819	.906	.994	1.08	1.17
75°	T=.27	.56	.83	1.12	1.40	1.69	1.98	2.27	2.57	2.87	3.16	3.47	3.78	4.09
	E=.095	.182	.286	.383	.480	.578	.678	.777	.877	.977	1.07	1.18	1.29	1.39
80°	T=.30	.61	.91	1.22	1.53	1.84	2.15	2.46	2.78	3.10	3.44	3.78	4.12	4.46
	E=.110	.220	.332	.445	.558	.671	.787	.903	1.02	1.13	1.25	1.38	1.50	1.62
85°	T=.33	.66	1.00	1.33	1.68	2.02	2.36	2.70	3.05	3.40	3.77	4.14	4.55	4.89
	E=.128	.259	.391	.524	.657	.790	.926	1.06	1.20	1.34	1.47	1.62	1.76	1.91

TABLE I. — Tangents and Externals to a 1° Curve. Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
85°	5250.3	2041.7	**92°**	5933.2	2518.5	**99°**	6708.6	3092.7
10′	5265.6	2052.1	10′	5950.5	2531.0	10′	6728.4	3107.7
20	5281.0	2062.5	20	5967.9	2543.5	20	6748.2	3122.9
30	5296.4	2073.0	30	5985.3	2556.0	30	6768.1	3138.1
40	5311.9	2083.5	40	6002.7	2568.6	40	6788.1	3153.3
50	5327.4	2094.1	50	6020.2	2581.3	50	6808.2	3168.7
86	5343.0	2104.7	**93**	6037.8	2594.0	**100**	6828.3	3184.1
10	5358.6	2115.3	10	6055.4	2606.8	10	6848.5	3199.6
20	5374.2	2126.0	20	6073.1	2619.7	20	6868.8	3215.1
30	5389.9	2136.7	30	6090.8	2632.6	30	6889.2	3230.8
40	5405.6	2147.5	40	6108.6	2645.5	40	6909.6	3246.5
50	5421.4	2158.4	50	6126.4	2658.5	50	6930.1	3262.3
87	5437.2	2169.2	**94**	6144.3	2671.6	**101**	6950.6	3278.1
10	5453.1	2180.2	10	6162.6	2684.7	10	6971.3	3294.1
20	5469.0	2191.1	20	6180.2	2697.9	20	6992.0	3310.1
30	5484.9	2202.2	30	6198.3	2711.2	30	7012.7	3326.1
40	5500.9	2213.2	40	6216.4	2724.5	40	7033.6	3342.3
50	5517.0	2224.3	50	6234.6	2737.9	50	7054.5	3358.5
88	5533.1	2235.5	**95**	6252.8	2751.3	**102**	7075.5	3374.9
10	5549.2	2246.7	10	6271.1	2764.8	10	7096.6	3391.2
20	5565.4	2258.0	20	6289.4	2778.3	20	7117.8	3407.7
30	5581.6	2269.3	30	6307.9	2792.0	30	7139.0	3424.3
40	5597.8	2280.6	40	6326.3	2805.6	40	7160.3	3440.9
50	5614.2	2292.0	50	6344.8	2819.4	50	7181.7	3457.6
89	5630.5	2303.5	**96**	6363.4	2833.2	**103**	7203.2	3474.4
10	5646.9	2315.0	10	6382.1	2847.0	10	7224.7	3491.3
20	5663.4	2326.6	20	6400.8	2861.0	20	7246.3	3508.2
30	5679.9	2338.2	30	6419.5	2875.0	30	7268.0	3525.2
40	5696.4	2349.8	40	6438.4	2889.0	40	7289.8	3542.4
50	5713.0	2361.5	50	6457.3	2903.1	50	7311.7	3559.6
90	5729.7	2373.3	**97**	6476.2	2917.3	**104**	7333.6	3576.8
10	5746.3	2385.1	10	6495.2	2931.6	10	7355.6	3594.2
20	5763.1	2397.0	20	6514.3	2945.9	20	7377.8	3611.7
30	5779.9	2408.9	30	6533.4	2960.3	30	7399.9	3629.2
40	5796.7	2420.9	40	6552.6	2974.7	40	7422.2	3646.8
50	5813.6	2432.9	50	6571.9	2989.2	50	7444.6	3664.5
91	5830.5	2444.9	**98**	6591.2	3003.8	**105**	7467.0	3682.3
10	5847.5	2457.1	10	6610.6	3018.4	10	7489.6	3700.2
20	5864.6	2469.3	20	6630.1	3033.1	20	7512.2	3718.2
30	5881.7	2481.5	30	6649.6	3047.9	30	7534.9	3736.2
40	5898.8	2493.8	40	6669.2	3062.8	40	7557.7	3754.4
50	5916.0	2506.1	50	6688.8	3077.7	50	7580.5	3772.6

Corrections to be Added (T = Tangent. E. = External.)

Int. Angle	Curve 5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
85°	T=.33	.66	1.00	1.33	1.68	2.02	2.36	2.70	3.05	3.40	3.77	4.14	4.55	4.89
	E=.128	.259	.391	.524	.657	.790	.926	1.06	1.20	1.34	1.47	1.62	1.76	1.91
90°	T=.36	.72	1.09	1.45	1.83	2.20	2.57	2.94	3.32	3.70	4.10	4.50	4.91	5.32
	E=.149	.299	.450	.603	.756	.910	1.07	1.22	1.38	1.54	1.70	1.87	2.03	2.20
95°	T=.39	.79	1.19	1.55	2.00	2.40	2.80	3.20	3.61	4.02	4.49	4.98	5.38	5.83
	E=.174	.350	.522	.706	.985	1.06	1.25	1.43	1.62	1.80	1.99	2.19	2.38	2.58
100°	T=.43	.86	1.30	1.74	2.18	2.62	3.06	3.50	3.95	4.40	4.88	5.37	5.85	6.34
	E=.200	.401	.604	.809	1.01	1.22	1.43	1.64	1.85	2.06	2.28	2.50	2.73	2.96
105°	T=.46	.94	1.42	1.90	2.38	2.87	3.34	3.84	4.35	4.84	5.35	5.87	6.40	6.93
	E=.220	.470	.700	.938	1.17	1.42	1.65	1.90	2.14	2.39	2.64	2.90	3.16	3.41

TABLE I. — Tangents and Externals to a 1° Curve. Chord = 100 ft.

Int. Angle	Tangent	External	Int. Angle	Tangent	External	Int. Angle	Tangent	External
106°	7603.5	3791.0	**111°**	8336.7	4386.1	**116°**	9169.4	5082.7
10′	7626.6	3809.4	10′	8362.7	4407.6	10′	9199.1	5107.9
20	7649.7	3827.9	20	8388.9	4429.2	20	9229.0	5133.3
30	7672.9	3846.5	30	8415.1	4450.9	30	9259.0	5158.8
40	7696.3	3865.2	40	8441.5	4472.7	40	9289.2	5184.5
50	7719.7	3884.0	50	8468.0	4494.6	50	9319.5	5210.3
107	7743.2	3902.9	**112**	8494.6	4516.6	**117**	9349.9	5236.2
10	7766.8	3921.9	10	8521.3	4538.8	10	9380.5	5262.3
20	7790.5	3940.9	20	8548.1	4561.1	20	9411.3	5288.6
30	7814.3	3960.1	30	8575.0	4583.4	30	9442.2	5315.0
40	7838.1	3979.4	40	8602.1	4606.0	40	9473.2	5341.5
50	7862.1	3998.7	50	8629.3	4628.6	50	9504.4	5368.2
108	7886.2	4018.2	**113**	8656.6	4651.3	**118**	9535.7	5395.1
10	7910.4	4037.8	10	8684.0	4674.2	10	9567.2	5422.1
20	7934.6	4057.4	20	8711.5	4697.2	20	9598.9	5449.2
30	7959.0	4077.2	30	8739.2	4720.3	30	9630.7	5476.5
40	7983.5	4097.1	40	8767.0	4743.6	40	9662.6	5504.0
50	8008.0	4117.0	50	8794.9	4766.9	50	9694.7	5531.7
109	8032.7	4137.1	**114**	8822.9	4790.4	**119**	9727.0	5559.4
10	8057.4	4157.3	10	8851.0	4814.1	10	9759.4	5587.4
20	8082.3	4177.5	20	8879.3	4837.8	20	9792.0	5615.5
30	8107.3	4197.9	30	8907.7	4861.7	30	9824.8	5643.8
40	8132.3	4218.4	40	8936.3	4885.7	40	9857.7	5672.2
50	8157.5	4239.0	50	8965.0	4909.9	50	9890.8	5700.9
110	8182.8	4259.7	**115**	8993.8	4934.1	**120**	9924.0	5729.7
10	8208.2	4280.5	10	9022.7	4958.6	10	9957.5	5758.6
20	8233.7	4301.4	20	9051.7	4983.1	20	9991.0	5787.7
30	8259.3	4322.4	30	9080.9	5007.8	30	10025.0	5817.0
40	8285.0	4343.6	40	9110.3	5032.6	40	10059.0	5846.5
50	8310.8	4364.8	50	9139.8	5057.6	50	10093.0	5876.1

Corrections to be Added (T = Tangent. E = External.)

Int. Angle	Curve 5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°
100°	T=.43	.86	1.30	1.74	2.18	2.62	3.06	3.50	3.95	4.40	4.88	5.37	5.85	6.34
	E=.200	.401	.604	.809	1.01	1.22	1.43	1.64	1.85	2.06	2.28	2.50	2.73	2.96
105°	T=.46	.94	1.42	1.90	2.38	2.87	3.34	3.84	4.35	4.84	5.35	5.87	6.40	6.93
	E=.230	.470	.700	.938	1.17	1.42	1.65	1.90	2.14	2.39	2.64	2.90	3.16	3.41
110°	T=.50	1.03	1.55	2.08	2.60	3.14	3.66	4.21	4.76	5.31	5.86	6.43	7.01	7.59
	E=.260	.535	.808	1.08	1.36	1.63	1.91	2.19	2.49	2.61	3.05	3.35	3.65	3.95
115°	T=.54	1.13	1.70	2.29	2.86	3.45	4.03	4.63	5.23	5.83	6.44	7.07	7.70	8.35
	E=.307	.624	.939	1.26	1.57	1.89	2.21	2.54	2.87	3.20	3.53	3.88	4.23	4.58
120°	T=.61	1.25	1.89	2.52	3.16	3.81	4.44	5.11	5.78	6.44	7.11	7.80	8.51	9.21
	E=.339	.720	1.03	1.45	1.82	2.20	2.56	2.95	3.33	3.72	4.10	4.50	4.91	5.32

Table II. — Radii, Ordinates and Deflections. Chord = 100 ft.

Deg.	Radius	Mid. Ord.	Tan. Dist.	Def. Dist.	Def. for 1 Ft.	Deg.	Radius	Mid. Ord.	Tan. Dist.	Def. Dist.	Def. for 1 Ft.
	ft.	ft.	ft.	ft.	′		ft.	ft.	ft.	ft.	′
0° 10′	34377.	.036	.145	.291	0.05	7°	819.0	1.528	6.105	12.21	2.10
20	17189.	.073	.291	.582	0.10	20′	781.8	1.600	6.395	12.79	2.20
30	11459.	.109	.436	.873	0.15	30	764.5	1.637	6.540	13.08	2.25
40	8594.4	.145	.582	1.164	0.20	40	747.9	1.673	6.685	13.37	2.30
50	6875.5	.182	.727	1.454	0.25	8	716.8	1.746	6.976	13.95	2.40
1	5729.6	.218	.873	1.745	0.30	20	688.2	1.819	7.266	14.53	2.50
10	4911.2	.255	1.018	2.036	0.35	30	674.7	1.855	7.411	14.82	2.55
20	4297.3	.291	1.164	2.327	0.40	40	661.7	1.892	7.556	15.11	2.60
30	3819.8	.327	1.309	2.618	0.45	9	637.3	1.965	7.846	15.69	2.70
40	3437.9	.364	1.454	2.909	0.50	20	614.6	2.037	8.136	16.27	2.80
50	3125.4	.400	1.600	3.200	0.55	30	603.8	2.074	8.281	16.56	2.85
2	2864.9	.436	1.745	3.490	0.60	40	593.4	2.110	8.426	16.85	2.90
10	2644.6	.473	1.891	3.781	0.65	10	573.7	2.183	8.716	17.43	3.00
20	2455.7	.509	2.036	4.072	0.70	30	546.4	2.292	9.150	18.30	3.15
30	2292.0	.545	2.181	4.363	0.75	11	521.7	2.402	9.585	19.16	3.30
40	2148.8	.582	2.327	4.654	0.80	30	499.1	2.511	10.02	20.04	3.45
50	2022.4	.618	2.472	4.945	0.85	12	478.3	2.620	10.45	20.91	3.60
3	1910.1	.655	2.618	5.235	0.90	30	459.3	2.730	10.89	21.77	3.75
10	1809.6	.691	2.763	5.526	0.95	13	441.7	2.839	11.32	22.64	3.90
20	1719.1	.727	2.908	5.817	1.00	30	425.4	2.949	11.75	23.51	4.05
30	1637.3	.764	3.054	6.108	1.05	14	410.3	3.058	12.18	24.37	4.20
40	1562.9	.800	3.199	6.398	1.10	30	396.2	3.168	12.62	25.24	4.35
50	1495.0	.836	3.345	6.689	1.15	15	383.1	3.277	13.05	26.11	4.50
4	1432.7	.873	3.490	6.980	1.20	30	370.8	3.387	13.49	26.97	4.65
10	1375.4	.909	3.635	7.271	1.25	16	359.3	3.496	13.92	27.84	4.80
20	1322.5	.945	3.718	7.561	1.30	30	348.5	3.606	14.35	28.70	4.95
30	1273.6	.982	3.926	7.852	1.35	17	338.3	3.716	14.78	29.56	5.10
40	1228.1	1.018	4.071	8.143	1.40	18	319.6	3.935	15.64	31.29	5.40
50	1185.8	1.055	4.217	8.433	1.45	19	302.9	4.155	16.51	33.01	5.70
5	1146.3	1.091	4.362	8.724	1.50	20	287.9	4.374	17.37	34.73	6.00
10	1109.3	1.127	4.507	9.014	1.55	21	274.4	4.594	18.22	36.44	6.30
20	1074.7	1.164	4.653	9.305	1.60	22	262.0	4.814	19.08	38.16	6.60
30	1042.1	1.200	4.798	9.596	1.65	23	250.8	5.035	19.94	39.87	6.90
40	1011.5	1.237	4.943	9.886	1.70	24	240.5	5.255	20.79	41.58	7.20
50	982.6	1.273	5.088	10.18	1.75	25	231.0	5.476	21.64	43.28	7.50
6	955.4	1.309	5.234	10.47	1.80	26	222.3	5.697	22.50	44.99	7.80
10	929.6	1.346	5.379	10.76	1.85	27	214.2	5.918	23.35	46.69	8.10
20	905.1	1.382	5.524	11.05	1.90	28	206.7	6.139	24.19	48.38	8.40
30	881.9	1.418	5.669	11.34	1.95	29	199.7	6.360	25.04	50.07	8.70
40	859.9	1.455	5.814	11.63	2.00	30	193.2	6.583	25.88	51.76	9.00

The middle ordinate in inches for any cord of length (C) is equal to .0012 C^2 multiplied by the middle ordinate taken from the above table. Thus, if it desired to bend a 30 ft. rail to fit a 10 degree curve, its middle ordinate should be .0012×900×2.183 or 2.36 inches.

Table III. Deflections for Sub Chords for Short Radius Curves.

Degree of Curve	Radius 50	$\frac{\frac{1}{2} \text{ sub chord}}{R}$ = sin of ½ def. angle				Length of arc for 100 ft.
	sin. ½ def. ang.	12.5 Ft.	15 Ft.	20 Ft.	25 Ft.	
30°	193.18	1° 51′	2° 17′	2° 58′	3° 43′	101.15
32°	181.39	1° 59′	2° 25′	3° 10′	3° 58′	101.33
34°	171.01	2° 06′	2° 33′	3° 21′	4° 12′	101.48
36°	161.80	2° 13′	2° 41′	3° 33′	4° 26′	101.66
38°	153.58	2° 20′	2° 49′	3° 44′	4° 40′	101.85
40°	146.19	2° 27′	2° 57′	3° 55′	4° 54′	102.06
42°	139.52	2° 34′	3° 05′	4° 07′	5° 08	102.29
44°	133.47	2° 41′	3° 13′	4° 18′	5° 22′	102.53
46°	127.97	2° 48′	3° 21′	4° 29′	5° 36′	102.76
48°	122.92	2° 55′	3° 29′	4° 40′	5° 50′	103.00
50°	118.31	3° 02′	3° 38′	4° 51′	6° 04′	103.24
52°	114.06	3° 09′	3° 46′	5° 02′	6° 17′	103.54
54°	110.11	3° 16′	3° 54′	5° 13′	6° 31′	103.84
56°	106.50	3° 22′	4° 02′	5° 23′	6° 44′	104.14
58°	103.14	3° 29′	4° 10′	5° 34′	6° 57′	104.43
60°	100.00	3° 35′	4° 18′	5° 44′	7° 11′	104.72

CURVE FORMULAS

$T = R \tan \frac{1}{2} I$	$R = T \cot. \frac{1}{2} I$	Chord def. $= \frac{\text{chord}^2}{R}$
$T = \frac{50 \tan \frac{1}{2} I}{\text{Sin. } \frac{1}{2} D}$	$R = \frac{50}{\text{Sin. } \frac{1}{2} D}$	No. chords $= \frac{I}{D}$
$\text{Sin. } \frac{1}{2} D = \frac{50}{R}$	$E = R \text{ ex. sec } \frac{1}{2} I$	Tan. def. $= \frac{1}{2}$ chord def.
$\text{Sin. } \frac{1}{2} D = \frac{50 \tan \frac{1}{2} I}{T}$	$E = T \tan \frac{1}{4} I$	

The square of any distance, divided by twice the radius, will equal the distance from tangent to curve, very nearly.

To find angle for a given distance and deflection.

Rule 1. Multiply the given distance by .01745 (def. for 1° for 1 ft. see Table II.), and divide given deflection by the product.

Rule 2. Multiply given deflection by 57.3, and divide the product by the given distance.

To find deflection for a given angle and distance. Multiply the angle by .01745, and the product by the distance.

GENERAL DATA

RIGHT ANGLE TRIANGLES. Square the altitude, divide by twice the base. Add quotient to base for hypotenuse.

Given Base 100, Alt. $10.10^2 \div 200 = .5$. $100 + .5 = 100.5$ hyp.

Given Hyp. 100, Alt. $25.25^2 \div 200 = 3.125$. $100 - 3.125 = 96.875 =$ Base.

Error in first example, .002; in last, .045.

To find Tons of Rail in one mile of track: multiply weight per yard by 11, and divide by 7.

LEVELING. The correction for curvature and refraction, in feet and decimals of feet is equal to $0.574d^2$, where d is the distance in miles. The correction for curvature alone is closely, $\frac{2}{3}d^2$. The combined correction is negative.

PROBABLE ERROR. If d_1, d_2, d_3, etc. are the discrepancies of various results from the mean, and if $\Sigma d^2 =$ the sum of the squares of these differences and $n =$ the number of observations, then the probable error of the mean $=$

$$\pm 0.6745 \sqrt{\frac{\Sigma d^2}{n(n-1)}}$$

SOLAR EPHEMERIS. Attention is called to the Solar Ephemeris for the current year, published by Keuffel & Esser Co., and furnished upon request. This handy booklet, $3\frac{3}{8}$x6 in., has about 190 pages of data very useful to the Surveyor; such as the adjustments of transits, levels and solar attachments; directions and tables for determining the meridian and the latitude from observations on the sun and Polaris; stadia measurements; magnetic declination; arithmetic constants, etc.

TABLE IV.—Minutes in Decimals of a Degree.

1′	.0167	11′	.1833	21′	.3500	31′	.5167	41′	.6833	51′	.8500
2	.0333	12	.2000	22	.3667	32	.5333	42	.7000	52	.8667
3	.0500	13	.2167	23	.3833	33	.5500	43	.7167	53	.8833
4	.0667	14	.2333	24	.4000	34	.5667	44	.7333	54	.9000
5	.0833	15	.2500	25	.4167	35	.5833	45	.7500	55	.9167
6	.1000	16	.2667	26	.4333	36	.6000	46	.7667	56	.9333
7	.1167	17	.2833	27	.4500	37	.6167	47	.7833	57	.9500
8	.1333	18	.3000	28	.4667	38	.6333	48	.8000	58	.9667
9	.1500	19	.3167	29	.4833	39	.6500	49	.8167	59	.9833
10	.1667	20	.3333	30	.5000	40	.6667	50	.8333	60	1.0000

TABLE V.—Inches in Decimals of a Foot.

1-16	3-32	1/8	3-16	1/4	5-16	3/8	1/2	5/8	3/4	7/8
.0052	.0078	.0104	.0156	.0208	.0260	.0313	.0417	.0521	.0625	.0729
1	2	3	4	5	6	7	8	9	10	11
.0833	.1667	.2500	.3333	.4167	.5000	.5833	.6667	.7500	.8333	.9167

Natural Trigonometrical Functions

Angle.	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.	
° ′							
0	0	0	1.	∞	∞	1.	90
10	.0029	.0029		343.8	343.8	1.	50
20	.0058	.0058		171.9	171.9	.99998	40
30	.0087	.0087		114.6	114.6	.99996	30
40	.0116	.0116	1.0001	85.94	85.94	.99993	20
50	.0145	.0145	1.0001	68.76	68.75	.99989	10
1	.0175	.0175	1.0002	57.30	57.29	.99985	89
10	.0204	.0204	1.0002	49.11	49.10	.99979	50
20	.0233	.0233	1.0003	42.98	42.96	.99973	40
30	.0262	.0262	1.0003	38.20	38.19	.99966	30
40	.0291	.0291	1.0004	34.38	34.37	.99958	20
50	.0320	.0320	1.0005	31.26	31.24	.99949	10
2	.0349	.0349	1.0006	28.65	28.64	.99939	88
10	.0378	.0378	1.0007	26.45	26.43	.99929	50
20	.0407	.0407	1.0008	24.56	24.54	.99917	40
30	.0436	.0437	1.0010	22.93	22.90	.99905	30
40	.0465	.0466	1.0011	21.49	21.47	.99892	20
50	.0494	.0495	1.0012	20.23	20.21	.99878	10
3	.0523	.0524	1.0014	19.11	19.08	.99863	87
10	.0552	.0553	1.0015	18.10	18.07	.99847	50
20	.0581	.0582	1.0017	17.20	17.17	.99831	40
30	.0610	.0612	1.0019	16.38	16.35	.99813	30
40	.0640	.0641	1.0020	15.64	15.60	.99795	20
50	.0669	.0670	1.0022	14.96	14.92	.99776	10
4	.0698	.0699	1.0024	14.34	14.30	.99756	86
10	.0727	.0729	1.0027	13.76	13.73	.99736	50
20	.0756	.0758	1.0029	13.23	13.20	.99714	40
30	.0785	.0787	1.0031	12.75	12.71	.99692	30
40	.0814	.0816	1.0033	12.29	12.25	.99668	20
50	.0843	.0846	1.0036	11.87	11.83	.99644	10
5	.0872	.0875	1.0038	11.47	11.43	.99619	85
10	.0901	.0904	1.0041	11.10	11.06	.99594	50
20	.0929	.0934	1.0043	10.76	10.71	.99567	40
30	.0958	.0963	1.0046	10.43	10.39	.99540	30
40	.0987	.0992	1.0049	10.13	10.08	.99511	20
50	.1016	.1022	1.0052	9.839	9.788	.99482	10
6	.1045	.1051	1.0055	9.567	9.514	.99452	84
10	.1074	.1080	1.0058	9.309	9.255	.99421	50
20	.1103	.1110	1.0061	9.065	9.010	.99390	40
30	.1132	.1139	1.0065	8.834	8.777	.99357	30
40	.1161	.1169	1.0068	8.614	8.556	.99324	20
50	.1190	.1198	1.0072	8.405	8.345	.99290	10
7	.1219	.1228	1.0075	8.206	8.144	.99255	83
10	.1248	.1257	1.0079	8.016	7.953	.99219	50
20	.1276	.1287	1.0082	7.834	7.770	.99182	40
30	.1305	.1317	1.0086	7.661	7.596	.99144	30
40	.1334	.1346	1.0090	7.496	7.429	.99106	20
50	.1363	.1376	1.0094	7.337	7.269	.99067	10
							82
	Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle ° ′

Angle.	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.	
° ′							
8	.1392	.1405	1.0098	7.185	7.115	.99027	82
10	.1421	.1435	1.0102	7.040	6.968	.98986	50
20	.1449	.1465	1.0107	6.900	6.827	.98944	40
30	.1478	.1495	1.0111	6.766	6.691	.98902	30
40	.1507	.1524	1.0115	6.636	6.561	.98858	20
50	.1536	.1554	1.0120	6.512	6.435	.98814	10
9	.1564	.1584	1.0125	6.394	6.314	.98769	81
10	.1593	.1614	1.0129	6.277	6.197	.98723	50
20	.1622	.1644	1.0134	6.166	6.084	.98676	40
30	.1650	.1673	1.0139	6.059	5.976	.98629	30
40	.1679	.1703	1.0144	5.955	5.871	.98580	20
50	.1708	.1733	1.0149	5.855	5.769	.98531	10
10	.1736	.1763	1.0154	5.759	5.671	.98481	80
10	.1765	.1793	1.0160	5.665	5.576	.98430	50
20	.1794	.1823	1.0165	5.575	5.485	.98378	40
30	.1822	.1853	1.0170	5.488	5.396	.98325	30
40	.1851	.1883	1.0176	5.403	5.309	.98272	20
50	.1880	.1914	1.0181	5.320	5.226	.98218	10
11	.1908	.1944	1.0187	5.241	5.145	.98163	79
10	.1937	.1974	1.0193	5.164	5.066	.98107	50
20	.1965	.2004	1.0199	5.089	4.989	.98050	40
30	.1994	.2035	1.0205	5.016	4.915	.97992	30
40	.2022	.2065	1.0211	4.945	4.843	.97934	20
50	.2051	.2095	1.0217	4.877	4.773	.97875	10
12	.2079	.2126	1.0223	4.810	4.705	.97815	78
10	.2108	.2156	1.0230	4.745	4.638	.97754	50
20	.2136	.2186	1.0236	4.682	4.574	.97692	40
30	.2164	.2217	1.0243	4.620	4.511	.97630	30
40	.2193	.2247	1.0249	4.560	4.449	.97566	20
50	.2221	.2278	1.0256	4.502	4.390	.97502	10
13	.2250	.2309	1.0263	4.445	4.331	.97437	77
10	.2278	.2339	1.0270	4.390	4.275	.97371	50
20	.2306	.2370	1.0277	4.336	4.219	.97304	40
30	.2334	.2401	1.0284	4.284	4.165	.97237	30
40	.2363	.2432	1.0291	4.232	4.113	.97169	20
50	.2391	.2462	1.0299	4.182	4.061	.97100	10
14	.2419	.2493	1.0306	4.133	4.011	.97030	76
10	.2447	.2524	1.0314	4.086	3.962	.96959	50
20	.2476	.2555	1.0321	4.039	3.914	.96887	40
30	.2504	.2586	1.0329	3.994	3.867	.96815	30
40	.2532	.2617	1.0337	3.949	3.821	.96742	20
50	.2560	.2648	1.0345	3.906	3.776	.96667	10
15	.2588	.2679	1.0353	3.864	3.732	.96593	75
10	.2616	.2711	1.0361	3.822	3.689	.96517	50
20	.2644	.2742	1.0369	3.782	3.647	.96440	40
30	.2672	.2773	1.0377	3.742	3.606	.96363	30
40	.2700	.2805	1.0386	3.703	3.566	.96285	20
50	.2728	.2836	1.0394	3.665	3.526	.96206	10
							74
	Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle ° ′

Natural Trigonometrical Functions

Angle.	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.		Angle.	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.	
° ′								° ′							
16	.2756	.2867	1.0403	3.624	3.487	.96126	74	24	.4067	.4452	1.0946	2.459	2.246	.91355	66
10	.2784	.2899	1.0412	3.592	3.450	.96046	50	10	.4094	.4487	1.0961	2.443	2.229	.91236	50
20	.2812	.2931	1.0423	3.556	3.412	.95964	40	20	.4120	.4522	1.0975	2.427	2.211	.91116	40
30	.2840	.2962	1.0429	3.521	3.376	.95882	30	30	.4147	.4557	1.0989	2.411	2.194	.00996	30
40	.2868	.2994	1.0438	3.487	3.340	.95799	20	40	.4173	.4592	1.1004	2.396	2.177	.90875	20
50	.2896	.3026	1.0448	3.453	3.305	.95715	10	50	.4200	.4628	1.1019	2.381	2.161	.90753	10
17	.2924	.3057	1.0457	3.420	3.271	.95630	73	25	.4226	.4663	1.1034	2.366	2.145	.90631	65
10	.2952	.3089	1.0466	3.388	3.237	.95545	50	10	.4253	.4699	1.1049	2.351	2.128	.90507	50
20	.2979	.3121	1.0476	3.357	3.204	.95459	40	20	.4279	.4734	1.1064	2.337	2.112	.90383	40
30	.3007	.3153	1.0485	3.326	3.172	.95372	30	30	.4305	.4770	1.1079	2.323	2.097	.90259	30
40	.3035	.3185	1.0495	3.295	3.140	.95284	20	40	.4331	.4806	1.1095	2.309	2.081	.90133	20
50	.3062	.3217	1.0505	3.265	3.108	.95195	10	50	.4358	.4841	1.1110	2.295	2.066	.90007	10
18	.3090	.3249	1.0515	3.236	3.078	.95106	72	26	.4384	.4877	1.1126	2.281	2.050	.89879	64
10	.3118	.3281	1.0525	3.207	3.048	.95015	50	10	.4410	.4913	1.1142	2.268	2.035	.89752	50
20	.3145	.3314	1.0535	3.179	3.018	.94924	40	20	.4436	.4950	1.1158	2.254	2.020	.89623	40
30	.3173	.3346	1.0545	3.152	2.989	.94832	30	30	.4462	.4986	1.1174	2.241	2.006	.89493	30
40	.3201	.3378	1.0555	3.124	2.960	.94740	20	40	.4488	.5022	1.1190	2.228	1.991	.89363	20
50	.3228	.3411	1.0566	3.098	2.932	.94646	10	50	.4514	.5059	1.1207	2.215	1.977	.89232	10
19	.3256	.3443	1.0576	3.072	2.904	.94552	71	27	.4540	.5095	1.1223	2.203	1.963	.89101	63
10	.3283	.3476	1.0587	3.046	2.877	.94457	50	10	.4566	.5132	1.1240	2.190	1.949	.88968	50
20	.3311	.3508	1.0598	3.020	2.850	.94361	40	20	.4592	.5169	1.1257	2.178	1.935	.88835	40
30	.3338	.3541	1.0608	2.996	2.824	.94264	30	30	.4617	.5206	1.1274	2.166	1.921	.88701	30
40	.3365	.3574	1.0619	2.971	2.798	.94167	20	40	.4643	.5243	1.1291	2.154	1.907	.88566	20
50	.3393	.3607	1.0631	2.947	2.773	.94068	10	50	.4669	.5280	1.1308	2.142	1.894	.88431	10
20	.3420	.3640	1.0642	2.924	2.747	.93969	70	28	.4695	.5317	1.1326	2.130	1.881	.88295	62
10	.3448	.3673	1.0653	2.900	2.723	.93869	50	10	.4720	.5354	1.1343	2.119	1.868	.88158	50
20	.3475	.3706	1.0665	2.878	2.699	.93769	40	20	.4746	.5392	1.1361	2.107	1.855	.88020	40
30	.3502	.3739	1.0676	2.856	2.675	.93667	30	30	.4772	.5430	1.1379	2.096	1.842	.87882	30
40	.3529	.3772	1.0688	2.833	2.651	.93565	20	40	.4797	.5467	1.1397	2.085	1.829	.87743	20
50	.3557	.3805	1.0700	2.811	2.628	.93462	10	50	.4823	.5505	1.1415	2.073	1.816	.87603	10
21	.3584	.3839	1.0711	2.790	2.605	.93358	69	29	.4848	.5543	1.1434	2.063	1.804	.87462	61
10	.3611	.3872	1.0723	2.769	2.583	.93253	50	10	.4874	.5581	1.1452	2.052	1.792	.87321	50
20	.3638	.3906	1.0736	2.749	2.560	.93148	40	20	.4899	.5619	1.1471	2.041	1.780	.87178	40
30	.3665	.3939	1.0748	2.729	2.539	.93042	30	30	.4924	.5658	1.1490	2.031	1.767	.87036	30
40	.3692	.3973	1.0760	2.709	2.517	.92935	20	40	.4950	.5696	1.1509	2.020	1.756	.86892	20
50	.3719	.4006	1.0773	2.689	2.496	.92827	10	50	.4975	.5735	1.1528	2.010	1.744	.86748	10
22	.3746	.4040	1.0785	2.670	2.475	.92718	68	30	.5000	.5774	1.1547	2.000	1.732	.86603	60
10	.3773	.4074	1.0798	2.650	2.455	.92609	50	10	.5025	.5812	1.1566	1.990	1.720	.86457	50
20	.3800	.4108	1.0811	2.632	2.434	.92499	40	20	.5050	.5851	1.1586	1.980	1.709	.86310	40
30	.3827	.4142	1.0824	2.613	2.414	.92388	30	30	.5075	.5890	1.1606	1.970	1.695	.86163	30
40	.3854	.4176	1.0837	2.595	2.394	.92276	20	40	.5100	.5930	1.1626	1.961	1.686	.86015	20
50	.3881	.4210	1.0850	2.577	2.375	.92164	10	50	.5125	.5969	1.1646	1.951	1.675	.85866	10
23	.3907	.4245	1.0864	2.559	2.356	.92050	67	31	.5150	.6009	1.1666	1.942	1.664	.85717	59
10	.3934	.4279	1.0877	2.542	2.337	.91936	50	10	.5175	.6048	1.1687	1.932	1.653	.85567	50
20	.3961	.4314	1.0891	2.525	2.318	.91822	40	20	.5200	.6088	1.1707	1.923	1.643	.85416	40
30	.3987	.4348	1.0904	2.508	2.300	.91706	30	30	.5225	.6128	1.1728	1.914	1.632	.85264	30
40	.4014	.4383	1.0918	2.491	2.282	.91590	20	40	.5250	.6168	1.1749	1.905	1.621	.85112	20
50	.4041	.4417	1.0932	2.475	2.264	.91472	10	50	.5275	.6208	1.1770	1.896	1.611	.84959	10
							66								58
	Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle		Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle
	° ′								°						

Natural Trigonometrical Functions

Angle.	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.	
° ′							° ′
32 .	.5299	.6249	1.1792	1.887	1.600	.84805	58
10	.5324	.6289	1.1813	1.878	1.590	.84650	50
20	.5348	.6330	1.1835	1.870	1.580	.84495	40
30	.5373	.6371	1.1857	1.861	1.570	.84339	30
40	.5398	.6412	1.1879	1.853	1.560	.84182	20
50	.5422	.6453	1.1901	1.844	1.550	.84025	10
33	.5446	.6494	1.1924	1.836	1.540	.83867	57
10	.5471	.6536	1.1946	1.828	1.530	.83708	50
20	.5495	.6577	1.1969	1.820	1.520	.83549	40
30	.5519	.6619	1.1992	1.812	1.511	.83389	30
40	.5544	.6661	1.2015	1.804	1.501	.83228	20
50	.5568	.6703	1.2039	1.796	1.492	.83066	10
34	.5592	.6745	1.2062	1.788	1.483	.82904	56
10	.5616	.6787	1.2086	1.781	1.473	.82741	50
20	.5640	.6830	1.2110	1.773	1.464	.82577	40
30	.5664	.6873	1.2134	1.766	1.455	.82413	30
40	.5688	.6916	1.2158	1.758	1.446	.82248	20
50	.5712	.6959	1.2183	1.751	1.437	.82082	10
35	.5736	.7002	1.2208	1.743	1.428	.81915	55
10	.5760	.7046	1.2233	1.736	1.419	.81748	50
20	.5783	.7089	1.2258	1.729	1.411	.81580	40
30	.5807	.7133	1.2283	1.722	1.402	.81412	30
40	.5831	.7177	1.2309	1.715	1.393	.81242	20
50	.5854	.7221	1.2335	1.708	1.385	.81072	10
36	.5878	.7265	1.2361	1.701	1.376	.80902	54
10	.5901	.7310	1.2387	1.695	1.368	.80730	50
20	.5925	.7355	1.2413	1.688	1.360	.80558	40
30	.5948	.7400	1.2440	1.681	1.351	.80386	30
40	.5972	.7445	1.2466	1.675	1.343	.80212	20
50	.5995	.7490	1.2494	1.668	1.335	.80038	10
37	.6018	.7536	1.2521	1.662	1.327	.79864	53
10	.6041	.7581	1.2549	1.655	1.319	.79688	50
20	.6065	.7627	1.2577	1.649	1.311	.79512	40
30	.6088	.7673	1.2605	1.643	1.303	.79335	30
40	.6111	.7720	1.2633	1.636	1.295	.79158	20
50	.6134	.7766	1.2661	1.630	1.288	.78980	10
38	.6157	.7813	1.2690	1.624	1.280	.78801	52
10	.6180	.7860	1.2719	1.618	1.272	.78622	50
20	.6202	.7907	1.2748	1.612	1.265	.78442	40
30	.6225	.7954	1.2778	1.606	1.257	.78261	30
40	.6248	.8002	1.2808	1.601	1.250	.78079	20
50	.6271	.8050	1.2838	1.595	1.242	.77897	10

Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle

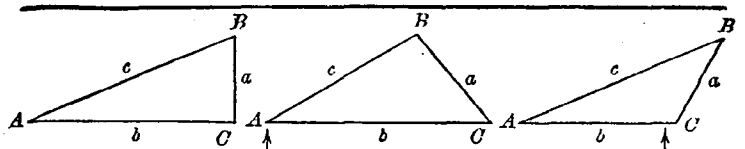
Angle.	Sin.	Tan.	Sec.	Cosec.	Cotg.	Cosin.	
° ′							° ′
39	.6293	.8098	1.2868	1.589	1.235	.77715	51
10	.6316	.8146	1.2898	1.583	1.228	.77531	50
20	.6338	.8195	1.2929	1.578	1.220	.77347	40
30	.6361	.8243	1.2959	1.572	1.213	.77162	30
40	.6383	.8292	1.2991	1.567	1.206	.76977	20
50	.6406	.8342	1.3022	1.561	1.199	.76791	10
40	.6428	.8391	1.3054	1.556	1.192	.76604	50
10	.6450	.8441	1.3086	1.550	1.185	.76417	50
20	.6472	.8491	1.3118	1.545	1.178	.76229	40
30	.6494	.8541	1.3151	1 540	1.171	.76041	30
40	.6517	.8591	1.3184	1.535	1.164	.75851	20
50	.6539	.8642	1.3217	1.529	1.157	.75661	10
41	.6561	.8693	1.3251	1.524	1.150	.75471	49
10	.6583	.8744	1.3284	1.519	1.144	.75280	50
20	.6604	.8796	1.3318	1.514	1.137	.75088	40
30	.6626	.8847	1.3352	1.509	1.130	.74896	30
40	.6648	.8899	1.3386	1.504	1.124	.74703	20
50	.6670	.8952	1.3421	1.499	1.117	.74509	10
42	.6691	.9004	1.3456	1.494	1.111	.74314	48
10	.6713	.9057	1.3492	1.490	1.104	.74120	50
20	.6734	.9110	1.3527	1.485	1.098	.73924	40
30	.6756	.9163	1.3563	1.480	1.091	.73728	30
40	.6777	.9217	1.3600	1.476	1.085	.73531	20
50	.6799	.9271	1.3636	1.471	1.079	.73333	10
43	.6820	.9325	1.3673	1.466	1.072	.73135	47
10	.6841	.9380	1.3711	1.462	1.066	.72937	50
20	.6862	.9435	1.3748	1.457	1.060	.72737	40
30	.6884	.9490	1.3786	1.453	1.054	.72537	30
40	.6905	.9545	1.3824	1.448	1.048	.72337	20
50	.6926	.9601	1.3863	1.444	1.042	.72136	10
44	.6947	.9657	1.3902	1.440	1.036	.71934	46
10	.6967	.9713	1.3941	1.435	1.030	.71732	50
20	.6988	.9770	1.3980	1.431	1.024	.71529	40
30	.7009	.9827	1.4020	1.427	1.018	.71325	30
40	.7030	.9884	1.4061	1.422	1.012	.71121	20
50	.7050	.9942	1.4101	1.418	1.006	.70916	10
	.7071	1.	1.414	1.414	1.	.70711	45

Cosin.	Cotg.	Cosec.	Sec.	Tan.	Sin.	Angle

	TCA	TCE	PCE	11DCA	111TCA
113	7.7	8.7	8.3		
119		280	1,100	22	240

micrograms per liter

TRIGONOMETRIC FORMULÆ



Right Triangle — Oblique Triangles

Solution of Right Triangles

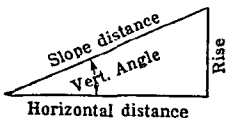
For Angle A. $\sin = \frac{a}{c}$, $\cos = \frac{b}{c}$, $\tan = \frac{a}{b}$, $\cot = \frac{b}{a}$, $\sec = \frac{c}{b}$, $\operatorname{cosec} = \frac{c}{a}$

Given	Required	
a, b	A, B, c	$\tan A = \frac{a}{b} = \cot B$, $c = \sqrt{a^2 + b^2} = a\sqrt{1 + \frac{b^2}{a^2}}$
a, c	A, B, b	$\sin A = \frac{a}{c} = \cos B$, $b = \sqrt{(c+a)(c-a)} = c\sqrt{1 - \frac{a^2}{c^2}}$
A, a	B, b, c	$B = 90° - A$, $b = a \cot A$, $c = \frac{a}{\sin A}$.
A, b	B, a, c	$B = 90° - A$, $a = b \tan A$, $c = \frac{b}{\cos A}$.
A, c	B, a, b	$B = 90° - A$, $a = c \sin A$, $b = c \cos A$,

Solution of Oblique Triangles

Given	Required	
A, B, a	b, c, C	$b = \frac{a \sin B}{\sin A}$, $C = 180° - (A + B)$, $c = \frac{a \sin C}{\sin A}$
A, a, b	B, c, C	$\sin B = \frac{b \sin A}{a}$, $C = 180° - (A + B)$, $c = \frac{a \sin C}{\sin A}$
a, b, C	A, B, c	$A + B = 180° - C$, $\tan \frac{1}{2}(A - B) = \frac{(a-b)\tan \frac{1}{2}(A+B)}{a+b}$, $c = \frac{a \sin C}{\sin A}$
a, b, c	A, B, C	$s = \frac{a+b+c}{2}$, $\sin \frac{1}{2}A = \sqrt{\frac{(s-b)(s-c)}{bc}}$, $\sin \frac{1}{2}B = \sqrt{\frac{(s-a)(s-c)}{ac}}$, $C = 180° - (A+B)$
a, b, c	Area	$s = \frac{a+b+c}{2}$, area $= \sqrt{s(s-a)(s-b)(s-c)}$
A, b, c	Area	area $= \frac{b\,c \sin A}{2}$
A, B, C, a	Area	area $= \frac{a^2 \sin B \sin C}{2 \sin A}$

REDUCTION TO HORIZONTAL



Horizontal distance = Slope distance multiplied by the cosine of the vertical angle. Thus: slope distance = 319.4 ft. Vert. angle = 5° 10′. From Table, Page IX. cos 5° 10′ = .9959. Horizontal distance = 319.4 × .9959 = 318.09 ft. Horizontal distance also = Slope distance minus slope distance times (1 — cosine of vertical angle). With the same figures as in the preceding example, the following result is obtained. Cosine 5° 10′ = .9959. 1 — .9959 = .0041. 319.4 × .0041 = 1.31. 319.4 — 1.31 = 318.09 ft.

When the rise is known, the horizontal distance is approximately:—the slope distance less the square of the rise divided by twice the slope distance. Thus: rise = 14 ft., slope distance = 302.6 ft. Horizontal distance $= 302.6 - \frac{14 \times 14}{2 \times 302.6} = 302.6 - 0.32 = 302.28$ ft.