SOFTWARE RELEASE NOTICE

01. SRN Number: PA-SRN-114

02. Project Title:
Hydrogeologic Flow Simulation, CNWRA Version 1.1

Project No.
20-5702-065

03. SRN Title: PORFLOW 1.0

04. Originator/Requestor: Budhi Sagar

Date: 01/22/96

05. Summary of Actions

- ☐ Release of new software
- ☐ Release of modified software:
  - ☐ Enhancements made
  - ☐ Corrections made
- ☐ Change of access software
- ■ Software Retirement

06. Persons Authorized Access

Name	RO/RW	A/C/D
N/A		

07. Element Manager Approval: R C Ryder

Date: 1/26/96

08. Remarks:

Not considered important to regulatory reviews in revised FY96 OPS Plans.

SOFTWARE RELEASE NOTICE

01. SRN Number: PA-SRN-005

02. Project Title: Hydrogeologic Flow Simulation, CNWRA Version 1.1

Project No.

03. SRN Title: Porflow 1.0

04. Originator/Requester: Thomas J. Ratchford

Date: 12/14/93

05. Summary of Actions

- ■ Release of new code admitted to CM System
- □ Release of modified code:
  - □ Enhancements made
  - □ Corrections made
- ■ Change of access code

06. Persons Authorized Access

Name	RO/RW	A/C/D

07. Element Manager Approval: Date:

08. Remarks:

CNWRA Form TOP-6 (08/93)

SOFTWARE SUMMARY FORM

01. Summary Date:	02. Summary prepared by (Name and phone)	03. Summary Action:
4/27/93	Mark V. Muller, 522-3222	
04. Software Date: February 1992	05. Software Title: PORFLOW	New

06. Short Title:	07. Internal Software ID:
PORFLOW 1.0	

08. Software Type:	09. Processing Mode:	10. APPLICATION AREA
☐ Automated Data System	☐ Interactive	a. General: ☒ Scientific/Engineering ☐ Bibliographic/Textual ☐ Process Control ☐ Management Business
☒ Computer Program	☐ Batch	☐ Computer Systems Support/Utility ☐ Other
☐ Subroutine/Module	☒ Combination	b. Specific: Hydrogeologic Flow Simulation Model

11. Submitting Organization and Address:	12. Technical Contact(s) and Phone:
CNWRA	Mikko Ahola, 522-5799 Budhi Sagar, 522-5252

13. Narrative:

PORFLOW - 3D finite difference code for solution of multiphase fluid flow, heat transfer, and mass transport problems is variably saturated porous or fractured media.

14. Keywords:

Multiphase; Finite-Differences; Fluid Flow; Heat; Saturated.

15. Computer Model and Manufacturer	16. Computer Operating System:	17. Programming Language(s):	18. Number of Source Program Statements:
Cray/XMP	UNICOS	FORTRAN	
19. Computer Memory Requirements:	**20. Tape Drives:**	**21. Disk/Drum Units:**	**22. Terminals:**
	N/A	N/A	N/A

23. Other Operational Requirements

None.

24. Software Availability:	25. Documentation Availability:
☐ Available ☐ Limited ☒ In-House ONLY ☐ Active ☐ Inactive	☒ Available ☐ Inadequate ☐ In-House ONLY

26. Submission Package Status:
CCB Acceptance Criteria: Met ☒ Not Met ☐ Software QA Assessment: Successful ☒ Unsuccessful ☐

Code Custodian: T. J. Ratcliffe et al. Date: 10/3/93

CNWRA Form TOP-4-1 (11/92)

```
total 2503
   2 VCS/                    1 coverage/               1 porflo.f.copy
   1 analysis/               1 hpm0/                   1 test/
2488 comp.l                  2 non-ansi.l              6 wkdir/

porflo_verll/VCS:
total 2737
   2 Makefile*               6 fluxp.F*                2 prop0.F*
  14 adata.F*                3 fsurf.F*                7 proper.F*
  43 aflow.F*                2 geodef.F*               4 propz.F*
   9 archiv.F*              14 geom.F*                 1 putf.F*
   3 archv2.F*               2 getrow.F*               3 resdu2.F*
   4 arrays.F*               3 grid.F*                 1 round.F*
   1 atitl.F*                8 harmon.F*               6 slvadi.F*
   1 autodt.F*               6 histr2.F*               5 slvchl.F*
   1 bcdcay.F*               4 histry.F*               6 slvgse.F*
   2 bcdflt.F*              15 init.F*                 8 slvitp.F*
   2 bcedge.F*              30 input.F*                2 slvsor.F*
   3 bcfo.F*                 2 input2.F*               2 soilc.F*
   4 bcpost.F*               2 input3.F*              10 solve.F*
   5 bcpre.F*                2 intabl.F*               4 sorcin.F*
   6 bcuser.F*               2 invert.F*               6 sourc9.F*
   2 bcuvw.F*                2 iofile.F*               7 source.F*
   7 blkprt.F*               2 iounit.F*               3 table2.F*
   5 bugset.F*               1 locnp.F*                6 tables.F*
   7 dattim.F*               1 locxyz.F*             640 texascray.f*
   1 dclaim.F*               3 outall.F*               2 timstp.F*
   1 delxyz.F*               2 outfl.F*               14 travel.F*
   5 densty.F*               1 outf2.F*                2 trnctr.F*
   6 difh.F*                 4 outsav.F*               1 tstat.F*
   2 disper.F*               4 outtr.F*               12 uspin.F*
   7 domain.F*               1 outvar.F*              11 usprp.F*
   2 errorl.F*               6 plalfa.F*               3 vel.F*
   2 error2.F*               1 plarea.F*               1 window.F*
   1 error3.F*               7 plprf.F*                1 x.porflo.cov*
   1 exist.F*                2 plprf2.F*               1 x.porflo.tes*
   1 expm.F*                11 plprp.F*                3 xalfa.F*
   5 fds.F*                168 porla.dat*              1 xnext.F*
   1 fdsexp.F*              13 porflo.F*               2 xside.F*
   4 fdsp.F*               472 porflo1.cpp*            7 xyplot.F*
   2 fix.F*                472 porflo1.f*              2 zname.F*
   3 flow.F*               472 porflo1.f.or*           7 zone.F*
  11 flux.F*                18 print.F*
   3 fluxl.F*                1 prntzn.F*

porflo_verll/analysis:
total 1287
   1 ANALYZ.CRD    2 porflo.ENT   24 porflo.VAL   14 porflo.pty
   2 porflo.ALT   13 porflo.FCN   16 porflo.cpx  320 porflo.rpt
  12 porflo.BLK  128 porflo.LCL   24 porflo.exp  472 porflo.src
 160 porflo.COM   23 porflo.PAR   63 porflo.met   13 porflo.tre

porflo_verll/coverage:
total 8140
  20 CUMSUM.ANA          1272 fort.21              768 porflo.f
  51 ESTATS                24 history.cum          168 porflo.post
  24 HISTORY                2 names.seg             88 porflo.tot
   0 PAST                2576 porla.plt             17 reportl.f77
1056 anotat.f77          1720 porflo*              176 summary.f77
   2 flow.data              1 porflo.covr.j         4 timehis
 168 fort.20                3 porflo.covr.l

porflo_verll/hpm0:
total 4035
 168 fort.20    1272 fort.21      15 perf.data  2576 porla.plt     4 timehis
```

```
porflo_verll/test:
total 88
   9 opt.rpt              14 perf.rpt              5 porflo.perf.1
  59 perf.data             1 porflo.perf.j

porflo_verll/wkdir:
total 7869
   1 .backslash           19 flow.l               18 print.f
   2 Makefile             11 flux.F               75 print.l
  14 adata.F              11 flux.f                1 prntzn.F
  14 adata.f              43 flux.l                1 prntzn.f
  46 adata.l               3 fluxl.F               7 prntzn.l
  43 aflow.F               3 fluxl.f               2 prop0.F
  43 aflow.f              15 fluxl.l               2 prop0.f
 216 aflow.l               6 fluxp.F               9 prop0.l
   9 archiv.F              6 fluxp.f               7 proper.F
   9 archiv.f             33 fluxp.l               7 proper.f
  46 archiv.l              3 fsurf.F              30 proper.l
   3 archv2.F              3 fsurf.f               4 propz.F
   3 archv2.f             23 fsurf.l               4 propz.f
  14 archv2.l              2 geodef.F             19 propz.l
   4 arrays.F              2 geodef.f              1 putf.F
   4 arrays.f              9 geodef.l              1 putf.f
  21 arrays.l             14 geom.F                8 putf.l
   1 atitl.F              14 geom.f                3 resdu2.F
   1 atitl.f              75 geom.l                3 resdu2.f
   8 atitl.l               2 getrow.F             20 resdu2.l
   1 autodt.F              2 getrow.f              1 round.F
   1 autodt.f              9 getrow.l              1 round.f
   7 autodt.l              3 grid.F                7 round.l
   1 bcdcay.F              3 grid.f                6 slvadi.F
   1 bcdcay.f             15 grid.l                6 slvadi.f
   7 bcdcay.l              8 harmon.F             35 slvadi.l
   2 bcdflt.F              8 harmon.f              5 slvchl.F
   2 bcdflt.f             46 harmon.l              5 slvchl.f
  10 bcdflt.l              6 histr2.F             32 slvchl.l
   2 bcedge.F              6 histr2.f              6 slvgse.F
   2 bcedge.f             26 histr2.l              6 slvgse.f
  12 bcedge.l              4 histry.F             37 slvgse.l
   3 bcfo.F                4 histry.f              8 slvitp.F
   3 bcfo.f               26 histry.l              8 slvitp.f
  14 bcfo.l               15 init.F               38 slvitp.l
   4 bcpost.F             15 init.f                2 slvsor.F
   4 bcpost.f             86 init.l                2 slvsor.f
  21 bcpost.l             30 input.F              11 slvsor.l
   5 bcpre.F              30 input.f               2 soilc.F
   5 bcpre.f             144 input.l               2 soilc.f
  26 bcpre.l               2 input2.F             12 soilc.l
   6 bcuser.F              2 input2.f             10 solve.F
   6 bcuser.f              9 input2.l             10 solve.f
  27 bcuser.l              2 input3.F             39 solve.l
   2 bcuvw.F               2 input3.f              4 sorcin.F
   2 bcuvw.f               8 input3.l              4 sorcin.f
  10 bcuvw.l               2 intabl.F             17 sorcin.l
   7 blkprt.F              2 intabl.f              6 sourc9.F
   7 blkprt.f              9 intabl.l              6 sourc9.f
  35 blkprt.l              2 invert.F             29 sourc9.l
   5 bugset.F              2 invert.f              7 source.F
   5 bugset.f             14 invert.l              7 source.f
  18 bugset.l              2 iofile.F             35 source.l
   7 dattim.F              2 iofile.f              3 table2.F
   7 dattim.f             10 iofile.l              3 table2.f
  24 dattim.l              2 iounit.F             17 table2.l
   1 dclaim.F              2 iounit.f              6 tables.F
   1 dclaim.f              8 iounit.l              6 tables.f
   5 dclaim.l              1 locnp.F              24 tables.l
```

```
  1 delxyz.F
  1 delxyz.f
  5 delxyz.l
  5 densty.F
  5 densty.f
 27 densty.l
  6 difh.F
  6 difh.f
 37 difh.l
  2 disper.F
  2 disper.f
 16 disper.l
  7 domain.F
  7 domain.f
 37 domain.l
  2 errorl.F
  2 errorl.f
  9 errorl.l
  2 error2.F
  2 error2.f
  9 error2.l
  1 error3.F
  1 error3.f
  8 error3.l
  1 exist.F
  1 exist.f
  6 exist.l
  1 expm.F
  1 expm.f
  6 expm.l
  5 fds.F
  5 fds.f
 33 fds.l
  1 fdsexp.F
  1 fdsexp.f
  7 fdsexp.l
  4 fdsp.F
  4 fdsp.f
 22 fdsp.l
  2 fix.F
  2 fix.f
 10 fix.l
  3 flow.F
  3 flow.f
  1 locnp.f
  8 locnp.l
  1 locxyz.F
  1 locxyz.f
  8 locxyz.l
  3 outall.F
  3 outall.f
 22 outall.l
  2 outfl.F
  2 outfl.f
 14 outfl.l
  1 outf2.F
  1 outf2.f
  7 outf2.l
  4 outsav.F
  4 outsav.f
 16 outsav.l
  4 outtr.F
  4 outtr.f
 18 outtr.l
  1 outvar.F
  1 outvar.f
  9 outvar.l
  6 plalfa.F
  6 plalfa.f
 36 plalfa.l
  1 plarea.F
  1 plarea.f
  5 plarea.l
  7 plprf.F
  7 plprf.f
 41 plprf.l
  2 plprf2.F
  2 plprf2.f
 16 plprf2.l
 11 plprp.F
 11 plprp.f
 59 plprp.l
1896 porflo*
 13 porflo.F
 13 porflo.f
 53 porflo.l
176 porflo.m
 18 print.F
640 texascray.f
1584 texascray.l
  2 timstp.F
  2 timstp.f
  8 timstp.l
 14 travel.F
 14 travel.f
 65 travel.l
  2 trnctr.F
  2 trnctr.f
  8 trnctr.l
  1 tstat.F
  1 tstat.f
  8 tstat.l
 12 uspin.F
 12 uspin.f
 54 uspin.l
 11 usprp.F
 11 usprp.f
 43 usprp.l
  3 vel.F
  3 vel.f
 15 vel.l
  1 window.F
  1 window.f
  9 window.l
  3 xalfa.F
  3 xalfa.f
 18 xalfa.l
  1 xnext.F
  1 xnext.f
  6 xnext.l
  2 xside.F
  2 xside.f
  8 xside.l
  7 xyplot.F
  7 xyplot.f
 35 xyplot.l
  2 zname.F
  2 zname.f
  7 zname.l
  7 zone.F
  7 zone.f
 29 zone.l
```

Reviewed on 2/9/94 and suggestions noted. Mishra Ahola

PORFLOW Fortran Program Static and Dynamic Analysis

June 29, 1993

Earl S. Marwil
John E. Tolli
Scientific Computing Unit
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1. Introduction

This analysis was performed on the Cray version of the software as provided by Southwest Research Institute (SwRI).

Several sample problems were supplied along with the source code. The program was analyzed using the Craft (Cross Reference Analysis of Fortran) tool, FORWARN, the Fortran 77 analyzer, and PC-Metric. These tools provide static analysis, coverage analysis, and complexity analysis.

One sample problem was used (por1a.dat). The sample problem does not execute when PORFLOW is loaded with a core preset of indefinite. The program was re-loaded with a core preset of zero to run the sample problem.

2. References

[1] N.H. Marshall and E.S. Marwil, Cross Reference Analysis of Fortran (CRAFT), EG&G-CATT-9198, EG&G Idaho, Inc., July 1991.
[2] Fortran 77 Analyzer User's Manual, National Bureau of Standards, NBS GCR 81-359, 1981
[3] FORWARN User's Guide, Quibus Enterprises, Inc., July 1991.
[4] PC-Metric User's Guide, SET Laboratories, Inc., 1987.

3. Functions

The PORFLOW program contains 101 Fortran routines.

PORFLOW has no alternate entry points.

PORFLOW has 1 extraneous routine: "autodt".

4. Common Block Irregularities

There are 76 common blocks in the PORFLOW program.

There are inconsistent declarations for common blocks "cdebug" and "chead".

There are 10 common blocks ("carr1", "carr2", "carr3", "carr4", "carr8", "cbc", "cmatrx", "cplt2", "cread", and "crkh") which are declared only once in the program. These common blocks might be eliminated and their contents made local to the routines which declare them.

There are 47 instances of a common block being declared in a routine in which none of its elements are otherwise referenced.

Variable "xmn" in common block "cplot" is defined but unused. Variable "thres" in common block "cprop5" is defined but unused. Variable "nmix" in common block "csolv4" is defined but unused.

There are 13 instances of a common block variable being undefined and unused.

Variables "pecfac" and "pecf" in common block "cnpi" are used but undefined.

Variable "ibc4" in common block "cbc" is possibly undefined. Variable "pecmxh" in common block "cnpi" is possibly undefined. Variables "iwskp" and "wskp" in common block "csolv9" are possibly undefined.

5. Interface Irregularities

Program module "aflow" passes a constant (0) to "geom" in argument number 8, which "geom" subsequently modifies.

There are 4 calls to "iofile" from "input" in which a variable of the wrong type (integer instead of logical) is passed to "iofile" in argument number 2. There is 1 call to "iounit" from "input" in which a variable of the wrong type (integer instead of logical) is passed to "iounit" in argument number 3.

6. Local Variable Irregularities

There are 410 instances of a parameter not being used in a module in which it is declared.

Variables "ldat", "ltim", and "usrn" are undefined and unused in module "dattim". Variables "jcc", "jel", and "kel" are undefined and unused in module "solve".

There are 15 instances of a local variable being defined and unused in a module in which it is declared.

Variable "big" is used but undefined in module "timstp".

Variables "ifmth" and "zz" in module "aflow" are possibly undefined. Variable "ifmth" in module "input" is possibly undefined. Variable "iz" in module "propz" is possibly undefined. Variable "ier" in module "slvitp" is possibly undefined. Variable "iz" in module "uspin" is possibly undefined.

There are 18 instances of dummy arguments going unused in the routines which declare them.

7. Fortran Extensions

Modules "porflo" and "dclaim" contain some lower case alphabetic characters in their active Fortran.

Program module "aflow" contains an entity name ("tremain") which is longer than 6 characters.

Common block "chead" contains mixed character and non-character items.

Program modules "porflo", "fluxp", "invert", "print", "prntzn", "table2", and "xyplot" contain format statement fields which are not separated by a comma.

Program module "adata" contains an internal write to an assumed size array.

8. Optimization

The following table summarizes the performance data gathered from execution of the sample problem. Only those routines exercised by the sample problem are shown (see "Coverage Analysis" for a list of routines not exercised by the sample problem, i.e., coverage = 0%). The table lists all program modules in descending order according to CPU time. To optimize code execution time, emphasis should be placed on those modules which appear highest in the listing.

The performance data show that a high percentage of the overall execution time (82.651%) is spent in the first 10 routines listed (ZONE, ADATA, LOCNP, HARMON, BCPRE, FSURF, BCPOST, SLVITP, XALFA, GEOM). This is due primarily to the following (applies to some or all of the 10 routines):

1) a low percentage of floating point operations which are performed in vector mode (%Vflops is small) (ZONE does no floating point operations, thus %Vflops cannot be calculated)

2) a high overhead factor for calls to LOCNP (IFact > 1)

3) a high level of memory conflicts in BCPOST (MC/MR > 1)

4) a high rate of instruction buffer fetches (IBFR > 1).

A detailed optimization analysis effort should focus on these 4 areas.

PERFORMANCE DATA FOR PORFLOW

ROUTINE NAME	Time	%ExTime	%AccumT	%Vflops	IFact	MC/MR	IBFR
ZONE	7.763	19.237	19.237	indef	0.00	0.057	0.276
ADATA	6.888	17.068	36.305	0.00000	0.02	0.176	0.565
LOCNP	4.706	11.661	47.966	0.00000	6104.42	0.907	1.173
HARMON	2.918	7.232	55.197	75.92188	0.00	0.094	0.000
BCPRE	2.354	5.833	61.030	0.00000	0.00	0.700	1.331
FSURF	2.290	5.675	66.705	0.00000	0.00	0.132	1.315
BCPOST	1.778	4.407	71.112	0.00000	0.00	1.502	0.000
SLVITP	1.598	3.959	75.071	0.00000	0.00	0.414	0.965
XALFA	1.552	3.845	78.916	0.00000	0.00	0.204	1.061
GEOM	1.507	3.734	82.651	11.55427	0.00	0.271	0.007
TABLE2	1.061	2.630	85.281	0.26264	0.00	0.325	1.060
PRBNDX	1.002	2.483	87.764	0.00000	0.00	0.368	0.000
SOURCE	0.725	1.797	89.561	0.00000	0.00	0.219	1.182
FLOW	0.474	1.174	90.735	99.99908	0.00	0.259	0.001
SOLVE	0.452	1.119	91.854	31.57731	0.00	0.173	0.001
VGATHR	0.338	0.838	92.692	0.00000	0.21	0.506	0.017
RESDU2	0.286	0.709	93.401	0.00000	0.00	0.240	0.000
FDSP	0.286	0.708	94.109	0.00000	0.00	0.712	0.000
FIX	0.268	0.664	94.773	0.00000	0.00	0.329	0.000
PRSRED	0.242	0.600	95.373	100.00000	0.00	0.246	0.026
SCAL	0.216	0.534	95.907	100.00000	0.00	0.167	0.002
AFLOW	0.203	0.504	96.411	0.00000	0.00	0.236	1.430
BCFO	0.134	0.332	96.743	0.00000	0.00	0.153	1.200
PRSBLK	0.125	0.310	97.052	100.00000	0.00	0.276	0.052
PRINT	0.119	0.294	97.347	0.00000	0.00	0.263	0.906
ITRSCG	0.102	0.253	97.600	99.97452	0.00	0.171	0.065
EXIST	0.098	0.243	97.843	0.00000	1.67	0.094	0.090
PRNTZN	0.095	0.235	98.078	0.00000	0.00	0.215	1.043
UNSCAL	0.089	0.220	98.298	100.00000	0.00	0.147	0.005
INPUT	0.077	0.191	98.489	81.93883	1.48	0.181	1.416
DIFH	0.064	0.158	98.647	0.00000	0.00	0.845	0.003
VSCATR	0.053	0.131	98.778	0.00000	0.01	0.515	0.009
PERMAT	0.049	0.123	98.900	0.00000	0.00	0.142	0.049
VGATHI	0.045	0.111	99.012	0.00000	0.01	0.655	0.008
VSCATI	0.041	0.102	99.114	0.00000	0.01	0.522	0.009
PROPZ	0.036	0.090	99.204	0.00000	1.59	0.319	0.478
GEODEF	0.036	0.088	99.292	0.00000	0.00	0.229	1.233
OUTVAR	0.028	0.071	99.363	0.00000	0.01	0.154	0.020
ARRAYS	0.026	0.065	99.428	0.00000	0.00	0.033	0.028
PUTF	0.025	0.062	99.490	0.00000	0.00	0.123	0.004
XYPLOT	0.025	0.062	99.551	22.51083	0.00	0.795	1.097
PMULT	0.022	0.055	99.606	100.00000	0.00	0.195	0.018
VEL	0.018	0.045	99.650	99.99666	0.00	0.127	0.003
PERROR	0.017	0.042	99.692	99.92413	0.00	0.102	0.011
RSCG	0.016	0.039	99.731	99.08777	0.00	0.103	0.181
INIT	0.014	0.034	99.765	72.90694	0.00	0.355	0.003
BCUVW	0.013	0.032	99.797	0.00000	0.00	0.076	0.013
PORFLO	0.012	0.030	99.827	0.00000	0.00	0.065	0.180
BLKPRT	0.009	0.022	99.850	0.00000	0.00	0.770	0.624

ROUTINE NAME	Time	%ExTime	%AccumT	%Vflops	IFact	MC/MR	IBFR
PERVEC	0.007	0.017	99.867	0.00000	0.00	0.147	0.037
DETERM	0.007	0.016	99.883	0.00000	0.74	1.419	0.229
DOMAIN	0.007	0.016	99.900	15.53684	0.00	0.139	0.017
ZBRENT	0.005	0.013	99.912	0.00000	0.04	1.128	1.051
WINDOW	0.005	0.011	99.924	62.50530	1.82	0.083	0.654
ARCHV2	0.004	0.010	99.934	0.00000	0.00	0.126	0.245
PSTOP	0.004	0.010	99.944	98.34065	0.09	0.153	0.256
ARCHIV	0.003	0.009	99.953	0.00000	0.00	0.184	0.711
DATTIM	0.003	0.007	99.959	0.00000	0.00	1.060	0.816
BCUSER	0.002	0.005	99.964	93.21372	0.00	0.082	0.065
TABLES	0.002	0.005	99.969	0.00000	0.00	0.125	0.156
IOUNIT	0.002	0.005	99.974	0.00000	0.00	0.535	0.637
HISTR2	0.001	0.004	99.977	0.00000	0.00	1.361	0.906
CHGCON	0.001	0.003	99.981	0.00000	0.17	1.885	1.147
EIGVSS	0.001	0.003	99.983	0.00000	0.17	0.829	0.834
PROPER	0.001	0.003	99.986	99.95719	0.00	0.359	0.005
ATITL	0.001	0.002	99.988	0.00000	0.00	1.782	0.950
PARCON	0.001	0.002	99.990	0.00000	0.41	3.943	0.475
BCEDGE	0.001	0.002	99.992	97.87234	0.01	0.181	0.264
HISTRY	0.001	0.002	99.993	0.00000	0.00	0.550	1.210
BCDFLT	0.001	0.001	99.995	0.00000	0.00	0.107	0.006
ITERM	0.000	0.001	99.996	0.00000	0.96	2.175	1.059
OUTSAV	0.000	0.001	99.997	0.00000	0.00	0.958	0.935
OUTALL	0.000	0.001	99.997	0.00000	0.00	0.050	0.116
ITICK	0.000	0.001	99.998	56.98631	0.10	1.442	0.685
GRID	0.000	0.001	99.998	62.03568	0.00	0.146	0.135
IOFILE	0.000	0.000	99.999	0.00000	0.00	0.144	0.629
DCLAIM	0.000	0.000	99.999	0.00000	0.00	0.254	0.770
ECHALL	0.000	0.000	99.999	0.00000	0.02	1.660	0.982
DENSTY	0.000	0.000	99.999	0.00000	0.03	0.705	1.708
PLALFA	0.000	0.000	100.000	0.00000	0.10	0.562	0.974
BUGSET	0.000	0.000	100.000	0.00000	0.03	0.573	1.026
PLPRP	0.000	0.000	100.000	0.00000	0.04	0.753	0.786
ZNAME	0.000	0.000	100.000	0.00000	0.00	0.277	0.785
OUTF1	0.000	0.000	100.000	0.00000	0.00	0.361	1.236
TSTAT	0.000	0.000	100.000	0.00000	0.00	0.883	0.866
INPUT2	0.000	0.000	100.000	88.88894	0.00	0.498	1.173
ROUND	0.000	0.000	100.000	0.00000	0.00	4.943	0.637
OUTF2	0.000	0.000	100.000	0.00000	0.01	0.543	0.000
DFAULT	0.000	0.000	100.000	0.00000	0.01	0.071	0.000
PROPO	0.000	0.000	100.000	0.00000	0.01	0.000	1.341
Totals (All Traced Routines)							
	40.357	100.000	100.000	54.62809	729.92	0.254	0.590

Key:

```
%AccumT - accumulated percentage of total CPU time
%ExTime - percentage of total CPU time
%Vflops - percentage of floating point operations due
          to vector floating point operations
IBFR    - Instruction Buffer Fetch Rate (megafetches/sec)
IFact   - Inline Factor (total calls to routine /
          average time spent in routine for each call)
MC      - number of memory conflicts
MR      - number of memory references
Time    - total CPU time (sec)
```

9. Coverage Analysis

One sample problem was executed. A coverage analysis shows that this problem yielded a 47% segment coverage of PORFLOW. Sample problems provided with simulation programs typically achieve 35% to 50% coverage. A statement of software quality cannot be made for routines that have low coverage, i.e., large portions of the code are untested.

Note that 36 routines have 0% coverage. These routines are not tested with the supplied sample problem.

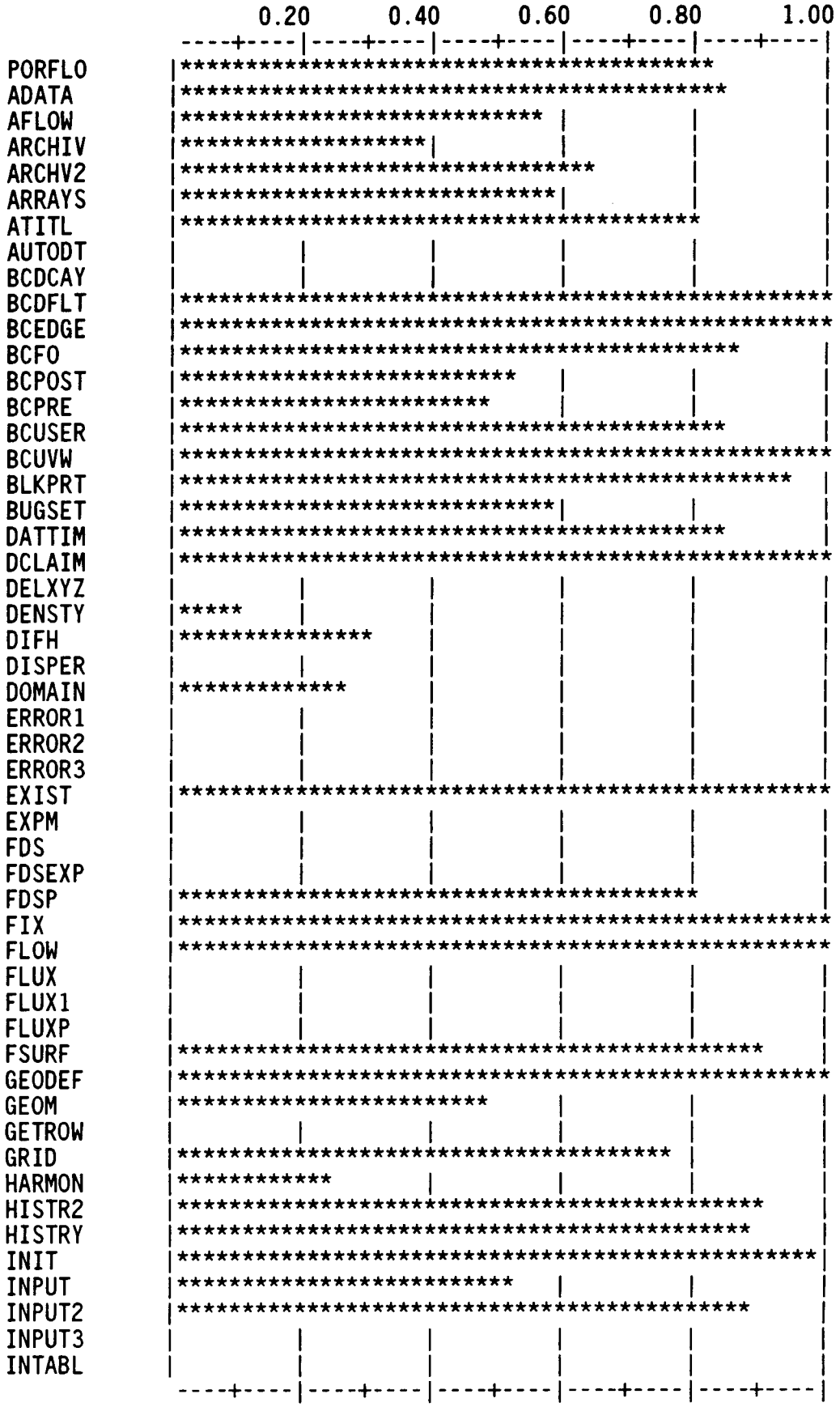
Four routines achieve 1%-19% coverage, 5 routines achieve 20%-39% coverage, 9 routines achieve 40%-59% coverage, 13 routines achieve 60%-79% coverage, 19 routines achieve 80%-99% coverage, and 15 routines achieve 100% coverage.

The following table shows the percent coverage for each routine.

Module Name	Number of Segments in module	Number of Segments Executed	Percent Segment Coverage
PORFLO	50	41	82.0
ADATA	102	85	83.3
AFLOW	258	143	55.4
ARCHIV	21	8	38.1
ARCHV2	17	11	64.7
ARRAYS	19	11	57.9
ATITL	10	8	80.0
AUTODT	3	0	0.0
BCDCAY	6	0	0.0
BCDFLT	10	10	100.0
BCEDGE	7	7	100.0
BCFO	21	18	85.7
BCPOST	17	9	52.9
BCPRE	19	9	47.4
BCUSER	24	20	83.3
BCUVW	13	13	100.0
BLKPRT	54	51	94.4
BUGSET	26	15	57.7
DATTIM	13	11	84.6

Module Name	Number of Segments in module	Number of Segments Executed	Percent Segment Coverage
DCLAIM	1	1	100.0
DELXYZ	1	0	0.0
DENSTY	22	2	9.1
DIFH	31	9	29.0
DISPER	6	0	0.0
DOMAIN	68	17	25.0
ERROR1	1	0	0.0
ERROR2	1	0	0.0
ERROR3	1	0	0.0
EXIST	5	5	100.0
EXPM	6	0	0.0
FDS	20	0	0.0
FDSEXP	1	0	0.0
FDSP	5	4	80.0
FIX	7	7	100.0
FLOW	16	16	100.0
FLUX	42	0	0.0
FLUX1	4	0	0.0
FLUXP	12	0	0.0
FSURF	19	17	89.5
GEODEF	8	8	100.0
GEOM	103	49	47.6
GETROW	5	0	0.0
GRID	24	18	75.0
HARMON	85	20	23.5
HISTR2	22	20	90.9
HISTRY	18	16	88.9
INIT	67	66	98.5
INPUT	239	126	52.7
INPUT2	9	8	88.9
INPUT3	5	0	0.0
INTABL	11	0	0.0
INVERT	10	0	0.0
IOFILE	16	14	87.5
IOUNIT	9	7	77.8
LOCNP	6	6	100.0
LOCXYZ	7	0	0.0
OUTALL	11	9	81.8
OUTF1	12	10	83.3
OUTF2	5	4	80.0
OUTSAV	10	6	60.0
OUTTR	25	0	0.0
OUTVAR	11	11	100.0
PLALFA	33	2	6.1
PLAREA	4	0	0.0
PLPRF	36	0	0.0
PLPRF2	8	0	0.0
PLPRP	74	2	2.7
PRINT	71	48	67.6
PRNTZN	6	6	100.0
PROPO	15	3	20.0

Module Name	Number of Segments in module	Number of Segments Executed	Percent Segment Coverage
PROPER	12	12	100.0
PROPZ	26	21	80.8
PUTF	9	7	77.8
RESDU2	14	11	78.6
ROUND	6	5	83.3
SLVADI	28	0	0.0
SLVCHL	48	0	0.0
SLVGSE	64	0	0.0
SLVITP	44	34	77.3
SLVSOR	3	0	0.0
SOILC	3	0	0.0
SOLVE	23	17	73.9
SORCIN	14	0	0.0
SOURC9	20	0	0.0
SOURCE	36	8	22.2
TABLE2	10	10	100.0
TABLES	21	15	71.4
TIMSTP	7	0	0.0
TRAVEL	99	0	0.0
TRNCTR	9	0	0.0
TSTAT	8	6	75.0
USPIN	76	0	0.0
USPRP	27	0	0.0
VEL	18	15	83.3
WINDOW	6	6	100.0
XALFA	14	12	85.7
XNEXT	4	0	0.0
XSIDE	10	0	0.0
XYPLOT	62	50	80.6
ZNAME	1	1	100.0
ZONE	51	21	41.2
Totals	2697	1258	46.6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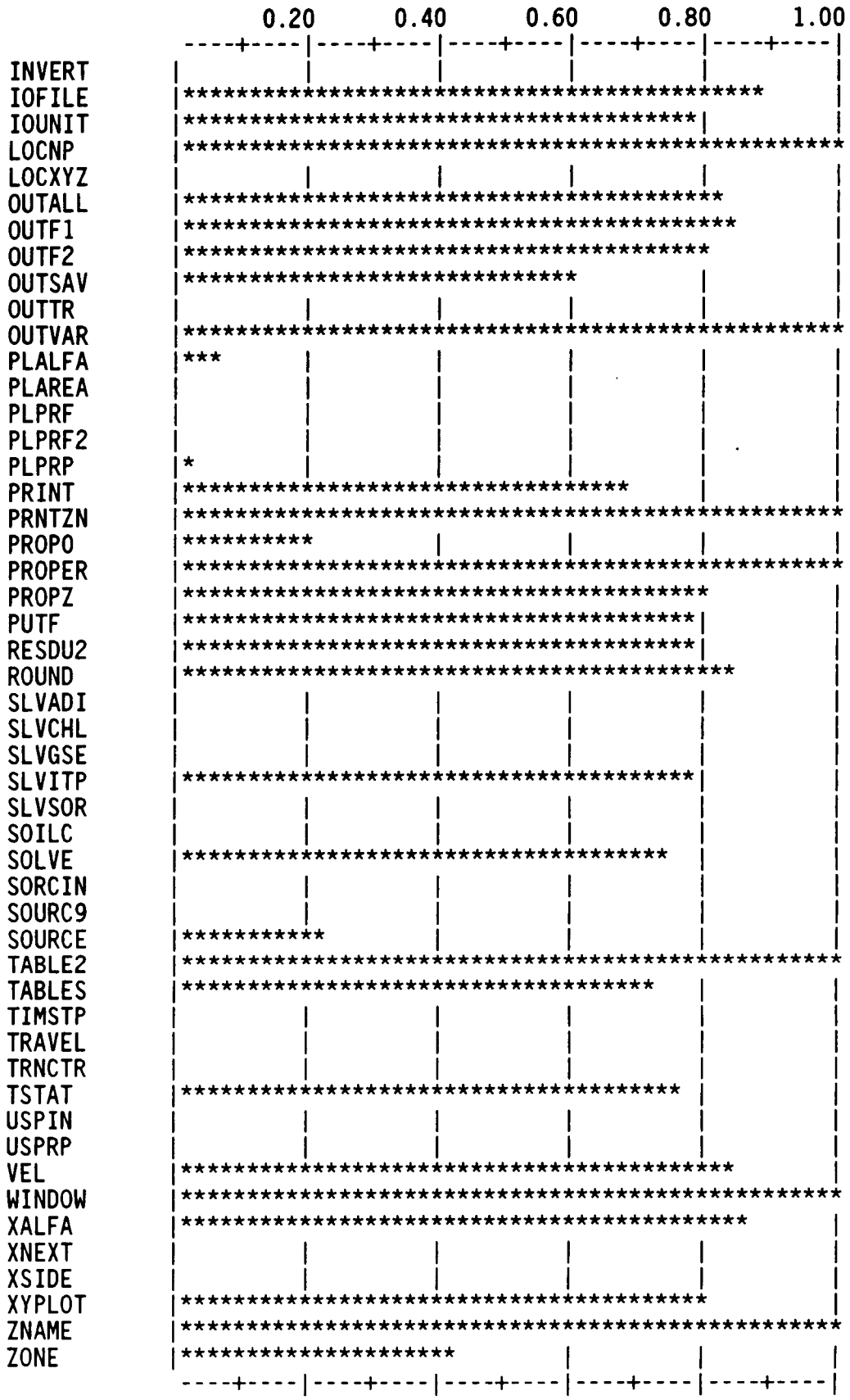
PORFLO
ADATA
AFLOW
ARCHIV
ARCHV2
ARRAYS
ATITL
AUTODT
BCDCAY
BCDFLT
BCEDGE
BCFO
BCPOST
BCPRE
BCUSER
BCUVW
BLKPRT
BUGSET
DATTIM
DCLAIM
DELXYZ
DENSTY
DIFH
DISPER
DOMAIN
ERROR1
ERROR2
ERROR3
EXIST
EXPM
FDS
FDSEXP
FDSP
FIX
FLOW
FLUX
FLUX1
FLUXP
FSURF
GEODEF
GEOM
GETROW
GRID
HARMON
HISTR2
HISTRY
INIT
INPUT
INPUT2
INPUT3
INTABL


0.20
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INVERT
IOFILE
IOUNIT
LOCNP
LOCXYZ
OUTALL
OUTF1
OUTF2
OUTSAV
OUTTR
OUTVAR
PLALFA
PLAREA
PLPRF
PLPRF2
PLPRP
PRINT
PRNTZN
PROPO
PROPER
PROPZ
PUTF
RESDU2
ROUND
SLVADI
SLVCHL
SLVGSE
SLVITP
SLVSOR
SOILC
SOLVE
SORCIN
SOURC9
SOURCE
TABLE2
TABLES
TIMSTP
TRAVEL
TRNCTR
TSTAT
USPIN
USPRP
VEL
WINDOW
XALFA
XNEXT
XSIDE
XYPLOT
ZNAME
ZONE

coverage = 0.	AUTODT	BCDCAY	DELXYZ	DISPER	ERROR1
	ERROR2	ERROR3	EXPM	FDS	FDSEXP
	FLUX	FLUX1	FLUXP	GETROW	INPUT3
	INTABL	INVERT	LOCXYZ	OUTTR	PLAREA
	PLPRF	PLPRF2	SLVADI	SLVCHL	SLVGSE
	SLVSOR	SOILC	SORCIN	SOURC9	TIMSTP
	TRAVEL	TRNCTR	USPIN	USPRP	XNEXT
	XSIDE				
0.01 <= coverage < 0.20	DENSTY	PLALFA	PLPRP	PROPO	
0.20 <= coverage < 0.40	ARCHIV	DIFH	DOMAIN	HARMON	SOURCE
0.40 <= coverage < 0.60	AFLOW	ARRAYS	BCPOST	BCPRE	BUGSET
	GEOM	INPUT	OUTSAV	ZONE	
0.60 <= coverage < 0.80	ARCHV2	ATITL	FDSP	GRID	IOUNIT
	OUTF2	PRINT	PUTF	RESDU2	SLVITP
	SOLVE	TABLES	TSTAT		
0.80 <= coverage < 0.85	PORFLO	ADATA	BCUSER	DATTIM	OUTALL
	OUTF1	PROPZ	ROUND	VEL	XYPLOT
0.85 <= coverage < 0.90	BCFO	FSURF	HISTRY	INPUT2	IOFILE
	XALFA				
0.90 <= coverage < 0.95	BLKPRT	HISTR2			
0.95 <= coverage < 1.00	INIT				
coverage = 1.00	BCDFLT	BCEDGE	BCUVW	DCLAIM	EXIST
	FIX	FLOW	GEODEF	LOCNP	OUTVAR
	PRNTZN	PROPER	TABLE2	WINDOW	ZNAME

Program coverage for this run =0.47

10. Complexity Analysis

Some key metrics are the number of executable statements (sloc), the number of non-blank comments (ncomt), McCabe's extended cyclomatic complexity (vg2), the number of branching statements (cgoto, ugoto, bIF, and lIF), and Halstead's predicted number of errors in (re)writing the code (bhat). Measures are normalized per 100 executable statements for ease of comparison and are listed in the table below.

The branching measures for this code indicate few unconditional GO TO statements and logical IFs for most program modules. This code appears to be fairly well structured.

Most routines have a reasonably good ratio of non-blank comments to source code.

McCabe's extended cyclomatic complexity (vg2), normalized per 100 lines of source code, indicates high values. Generally, the routines with the highest complexity are those most likely to have defects. As a guideline, normalized measures of 15 or greater should be considered complex. A software maintenance program should focus on those routines with the highest measures.

Complexity Report by Subprogram for PORFLOW

Name	loc	sloc	cmnt	ncomt	ncomt /sloc	vg2 /sloc	cgoto	cgoto /sloc	ugoto	ugoto /sloc	bIF	bif /sloc	lIF	lif /sloc	Bhat
porflo	364	133	173	105	78.9	21.1	0	0.0	3	2.3	4	3.0	12	9.0	2
ADATA	405	183	223	124	67.8	33.9	0	0.0	11	6.0	13	7.1	16	8.7	3
AFLOW	1152	528	501	311	58.9	26.3	0	0.0	28	5.3	42	8.0	63	11.9	15
ARCHIV	189	74	84	59	79.7	12.2	0	0.0	0	0.0	3	4.1	4	5.4	3
ARCHV2	67	28	39	25	89.3	25.0	0	0.0	1	3.6	3	10.7	2	7.1	0
ARRAYS	88	35	43	24	68.6	37.1	0	0.0	0	0.0	1	2.9	4	11.4	0
ATITL	29	15	12	4	26.7	40.0	0	0.0	2	13.3	0	0.0	2	13.3	0
AUTODT	17	10	8	3	30.0	20.0	0	0.0	0	0.0	0	0.0	0	0.0	0
BCDCAY	21	8	16	7	87.5	50.0	0	0.0	0	0.0	1	12.5	1	12.5	0
BCDFLT	39	16	23	13	81.3	31.3	0	0.0	0	0.0	2	12.5	0	0.0	0
BCEDGE	35	21	16	8	38.1	19.0	0	0.0	0	0.0	0	0.0	0	0.0	1
BCFO	73	36	39	22	61.1	30.6	0	0.0	0	0.0	6	16.7	0	0.0	0
BCPOST	87	36	41	28	77.8	25.0	0	0.0	0	0.0	4	11.1	1	2.8	1
BCPRE	115	50	53	38	76.0	20.0	0	0.0	0	0.0	4	8.0	2	4.0	1
BCUSER	148	86	59	43	50.0	17.4	0	0.0	0	0.0	2	2.3	0	0.0	1
BCUVW	33	19	15	7	36.8	36.8	0	0.0	0	0.0	0	0.0	0	0.0	0
BLKPRT	195	83	54	9	10.8	31.3	0	0.0	9	10.8	2	2.4	9	10.8	1
BUGSET	126	41	80	50	122.0	41.5	0	0.0	0	0.0	2	4.9	5	12.2	1
DATTIM	205	44	119	70	159.1	13.6	0	0.0	3	6.8	1	2.3	2	4.5	1
DCLAIM	15	4	11	4	100.0	25.0	0	0.0	0	0.0	0	0.0	0	0.0	0
DELXYZ	13	2	14	8	400.0	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0
DENSTY	130	52	65	33	63.5	25.0	0	0.0	0	0.0	4	7.7	1	1.9	1
DIFH	151	76	48	26	34.2	23.7	0	0.0	0	0.0	7	9.2	2	2.6	2
DISPER	48	25	20	10	40.0	16.0	0	0.0	0	0.0	0	0.0	0	0.0	1
DOMAIN	216	123	85	37	30.1	29.3	0	0.0	1	0.8	12	9.8	3	2.4	2
ERROR1	19	3	11	6	200.0	33.3	0	0.0	0	0.0	0	0.0	0	0.0	0
ERROR2	21	3	13	6	200.0	33.3	0	0.0	0	0.0	0	0.0	0	0.0	0
ERROR3	16	5	10	2	40.0	20.0	0	0.0	0	0.0	0	0.0	0	0.0	0
EXIST	13	6	10	4	66.7	50.0	0	0.0	0	0.0	0	0.0	1	16.7	0
EXPM	19	8	15	9	112.5	37.5	0	0.0	0	0.0	1	12.5	0	0.0	0
FDS	133	75	52	24	32.0	14.7	0	0.0	0	0.0	1	1.3	1	1.3	1
FDSEXP	16	9	12	6	66.7	11.1	0	0.0	0	0.0	0	0.0	0	0.0	0
FDSP	89	20	50	32	160.0	15.0	0	0.0	0	0.0	0	0.0	1	5.0	0
FIX	36	18	20	11	61.1	27.8	0	0.0	0	0.0	1	5.6	0	0.0	0
FLOW	57	20	29	17	85.0	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0
FLUX	265	81	168	137	169.1	37.0	0	0.0	0	0.0	9	11.1	4	4.9	1

Name	loc	sloc	cmnt	ncomt	ncomt /sloc	vg2 /sloc	cgoto	cgoto /sloc	ugoto	ugoto /sloc	bIF	bif /sloc	lIF	lif /sloc	Bhat
FLUX1	51	11	28	17	154.5	18.2	0	0.0	0	0.0	1	9.1	0	0.0	0
FLUXP	112	39	37	29	74.4	15.4	0	0.0	0	0.0	1	2.6	3	7.7	1
FSURF	77	36	26	14	38.9	27.8	0	0.0	2	5.6	2	5.6	1	2.8	1
GEODEF	28	17	46	42	247.1	29.4	0	0.0	0	0.0	1	5.9	0	0.0	0
GEOM	363	217	135	60	27.6	25.8	0	0.0	1	0.5	9	4.1	7	3.2	4
GETROW	29	9	21	12	133.3	33.3	0	0.0	0	0.0	0	0.0	0	0.0	0
GRID	68	47	26	9	19.1	27.7	0	0.0	1	2.1	3	6.4	3	6.4	1
HARMON	203	122	71	34	27.9	41.8	0	0.0	0	0.0	8	6.6	4	3.3	2
HISTR2	144	49	83	52	106.1	26.5	0	0.0	1	2.0	2	4.1	3	6.1	1
HISTRY	112	50	47	22	44.0	18.0	0	0.0	1	2.0	3	6.0	3	6.0	1
INIT	482	234	177	101	43.2	13.7	0	0.0	0	0.0	1	0.4	1	0.4	3
INPUT	741	423	283	187	44.2	33.6	0	0.0	0	0.0	13	3.1	58	13.7	10
INPUT2	32	13	19	9	69.2	38.5	0	0.0	0	0.0	2	15.4	0	0.0	0
INPUT3	31	13	19	9	69.2	23.1	0	0.0	0	0.0	0	0.0	1	7.7	0
INTABL	40	22	23	12	54.5	27.3	0	0.0	2	9.1	1	4.5	2	9.1	0
INVERT	54	21	32	18	85.7	28.6	0	0.0	0	0.0	1	4.8	1	4.8	0
IOFILE	51	27	28	19	70.4	33.3	0	0.0	1	3.7	4	14.8	2	7.4	0
IOUNIT	40	18	22	14	77.8	22.2	0	0.0	0	0.0	3	16.7	0	0.0	0
LOCNP	26	16	11	7	43.8	18.8	0	0.0	0	0.0	1	6.3	0	0.0	0
LOCXYZ	31	13	17	7	53.8	30.8	0	0.0	0	0.0	1	7.7	0	0.0	0
OUTALL	78	31	29	16	51.6	19.4	0	0.0	0	0.0	1	3.2	2	6.5	0
OUTF1	56	17	31	16	94.1	41.2	0	0.0	0	0.0	1	5.9	4	23.5	0
OUTF2	20	7	18	9	128.6	42.9	0	0.0	0	0.0	0	0.0	1	14.3	0
OUTSAV	91	24	56	41	170.8	20.8	0	0.0	0	0.0	2	8.3	1	4.2	0
OUTTR	76	37	20	10	27.0	35.1	0	0.0	0	0.0	0	0.0	9	24.3	1
OUTVAR	26	16	12	5	31.3	37.5	0	0.0	0	0.0	1	6.3	1	6.3	0
PLALFA	138	73	46	28	38.4	26.0	0	0.0	0	0.0	6	8.2	2	2.7	1
PLAREA	13	6	11	5	83.3	33.3	0	0.0	0	0.0	1	16.7	0	0.0	0
PLPRF	189	86	91	43	50.0	29.1	0	0.0	0	0.0	5	5.8	2	2.3	1
PLPRF2	45	13	26	15	115.4	38.5	0	0.0	0	0.0	2	15.4	1	7.7	0
PLPRP	288	135	131	69	51.1	32.6	0	0.0	0	0.0	9	6.7	13	9.6	2
PRINT	466	144	194	119	82.6	26.4	0	0.0	0	0.0	12	8.3	11	7.6	4
PRNTZN	18	6	13	6	100.0	50.0	0	0.0	0	0.0	1	16.7	0	0.0	0
PROPO	34	20	18	9	45.0	50.0	0	0.0	0	0.0	3	15.0	4	20.0	0
PROPER	156	47	91	68	144.7	12.8	0	0.0	0	0.0	2	4.3	0	0.0	1
PROPZ	109	72	38	19	26.4	18.1	0	0.0	1	1.4	3	4.2	6	8.3	1
PUTF	30	15	17	7	46.7	40.0	0	0.0	0	0.0	1	6.7	0	0.0	0
RESDU2	77	28	32	20	71.4	21.4	0	0.0	0	0.0	4	14.3	0	0.0	0
ROUND	21	13	13	7	53.8	23.1	0	0.0	0	0.0	1	7.7	1	7.7	0

Name	loc	sloc	cmnt	ncomt	ncomt /sloc	vg2 /sloc	cgoto	cgoto /sloc	ugoto	ugoto /sloc	bIF	bif /sloc	lIF	lif /sloc	Bhat
SLVADI	162	75	73	24	32.0	22.7	0	0.0	0	0.0	3	4.0	0	0.0	1
SLVCHL	156	100	54	18	18.0	25.0	0	0.0	2	2.0	4	4.0	7	7.0	2
SLVGSE	167	120	54	19	15.8	32.5	0	0.0	2	1.7	3	2.5	18	15.0	2
SLVITP	236	81	125	81	100.0	28.4	0	0.0	0	0.0	3	3.7	0	0.0	2
SLVSOR	38	16	19	8	50.0	12.5	0	0.0	0	0.0	0	0.0	0	0.0	0
SOILC	30	7	16	10	142.9	28.6	0	0.0	0	0.0	0	0.0	0	0.0	0
SOLVE	258	47	179	111	236.2	27.7	0	0.0	0	0.0	3	6.4	1	2.1	1
SORCIN	83	30	46	29	96.7	30.0	0	0.0	0	0.0	1	3.3	6	20.0	1
SOURC9	137	42	69	43	102.4	28.6	0	0.0	0	0.0	2	4.8	3	7.1	1
SOURCE	175	70	92	51	72.9	27.1	0	0.0	1	1.4	5	7.1	3	4.3	1
TABLE2	59	29	29	13	44.8	17.2	0	0.0	1	3.4	0	0.0	1	3.4	1
TABLES	154	60	83	51	85.0	16.7	0	0.0	0	0.0	5	8.3	1	1.7	1
TIMSTP	30	12	19	14	116.7	33.3	0	0.0	0	0.0	2	16.7	0	0.0	0
TRAVEL	425	220	167	94	42.7	25.5	0	0.0	17	7.7	33	15.0	3	1.4	3
TRNCTR	51	18	36	22	122.2	27.8	0	0.0	0	0.0	3	16.7	0	0.0	0
TSTAT	27	16	16	5	31.3	25.0	0	0.0	0	0.0	1	6.3	2	12.5	0
USPIN	314	138	138	110	79.7	31.2	0	0.0	1	0.7	16	11.6	11	8.0	2
USPRP	246	61	150	119	195.1	26.2	0	0.0	0	0.0	6	9.8	2	3.3	2
VEL	78	35	43	27	77.1	28.6	0	0.0	0	0.0	2	5.7	2	5.7	1
WINDOW	29	17	14	5	29.4	29.4	0	0.0	0	0.0	1	5.9	0	0.0	0
XALFA	64	21	26	18	85.7	33.3	0	0.0	0	0.0	3	14.3	0	0.0	0
XNEXT	14	6	13	8	133.3	33.3	0	0.0	0	0.0	1	16.7	0	0.0	0
XSIDE	46	15	35	24	160.0	33.3	0	0.0	0	0.0	3	20.0	1	6.7	0
XYPLOT	192	118	67	31	26.3	22.9	0	0.0	7	5.9	3	2.5	7	5.9	2
ZNAME	31	20	14	7	35.0	5.0	0	0.0	0	0.0	0	0.0	0	0.0	0
ZONE	202	102	97	50	49.0	26.5	0	0.0	1	1.0	7	6.9	5	4.9	1

Σ BHAT = 97.0

Legend of Metrics in Report

loc -- lines of code
sloc -- number of executable statements
cmnt -- total number of commnts
ncomt -- number of non-blank COMMENT statements
100*ncomt/sloc -- percent, nonblank comments to number of executable statements
100*vg2/sloc -- percent, extended complexity of number of executable statements
cgoto -- number of COMPUTED GO TO statements
100*cgoto/sloc -- percent, computed GOTO's to number of executable statements
ugoto -- number of UNCONDITIONAL GO TO statements
100*ugoto/sloc -- percent, unconditional GOTO's to number of executable statements
bIF -- number of BLOCK IF statements
100*bif/sloc -- percent, Block IF statements to number of executable statements
lIF -- number of LOGICAL IF statements
100*lif/sloc -- percent, logical IF statements to number of executable statements
Bhat -- Halstead's predicted number of errors in writing code