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		Date May 8, 1995			
Project Title/Work Order GXQ Program Verification and Validation (D1DBA)		EDT No. 141670			
		ECN No. 609885			

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ENGINEERING CHANGE NOTICE

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1. ECN 609885

Proj.
ECN

2. ECN Category (mark one) Supplemental ☐ Direct Revision ☒ Change ECN ☐ Temporary ☐ Standby ☐ Supersedeure ☐ Cancel/Void ☐		3. Originator's Name, Organization, MSIN, and Telephone No. B. E. Hey/Criticality & Radiological Analyses/ H4-64/376-2921 8M400		3a. USQ Required? ☐ Yes ☒ No		4. Date 12/19/94	
		5. Project Title/No./Work Order No. GXQ Program Verification and Validation/DIDBA		6. Bldg./Sys./Fac. No. Software		7. Approval Designator ESQ	
		8. Document Numbers Changed by this ECN (includes sheet no. and rev.) WHC - SD - GN - SWD - 30003 Rev.0		9. Related ECN No(s). N/A		10. Related PO No. N/A	
11a. Modification Work ☐ Yes (fill out Blk. 11b) ☒ No (NA Blks. 11b, 11c, 11d)		11b. Work Package No. N/A		11c. Modification Work Complete N/A Cog. Engineer Signature & Date		11d. Restored to Original Condition (Temp. or Standby ECN only) N/A Cog. Engineer Signature & Date	
12. Description of Change Update of GXQ Program Verification and Validation for Version 4.0.							
13a. Justification (mark one) Criteria Change ☐ Design Improvement ☒ Environmental ☐ Facility Deactivation ☐ As-Found ☐ Facilitate Const ☐ Const. Error/Omission ☐ Design Error/Omission ☐							
13b. Justification Details The changes brought about by this ECN ensures consistency between the verification and validation and the program test cases for GXQ Version 4.0.							
14. Distribution (include name, MSIN, and no. of copies) B. E. Hey H4-64 A. L. Ramble H4-64 QA Manager Safety Environmental Peer Review						RELEASE STAMP OFFICIAL RELEASE 21 BY VHC DATE MAY 10 1995 Sta. 21	

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RELEASE AUTHORIZATION

Document Number: WHC-SD-GN-SWD-30003, Rev. 1

Document Title: GXQ Program Verification and Validation

Release Date: 5/09/95

**This document was reviewed following the
procedures described in WHC-CM-3-4 and is:**

APPROVED FOR PUBLIC RELEASE

WHC Information Release Administration Specialist:

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5. Key Words Atmospheric Dispersion, X/Q	6. Author Name: B. E. Hey Signature Organization/Charge Code 8M400/D1DBA	
7. Abstract <p>This report documents the program user's guide of a general purpose atmospheric dispersion code named GXQ. GXQ is an IBM Compatible microcomputer based program for calculating atmospheric dispersion coefficients using Hanford site specific joint frequency data. It uses the Gaussian straight line model to calculate either an atmospheric dispersion coefficient (X/Q') or a maximum normalized air concentration (X/Q). Several options are available to the user which alter the standard Gaussian model to allow for plume depletion, building wake, plume meander, sector averaging, gravitational settling and plume rise. Additional options control handling of the joint frequency data and output. Combinations of the above allow calculation of X/Q' in accordance with Nuclear Regulatory Commission Regulatory Guide 1.145.</p>		
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GXQ Program Verification and Validation

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(6) Cog. Mgr. Date

1	RS	Complete replacement. ECN-609085, 5/10/95
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B. E. Hey	A. L. Ramble
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GXQ 4.0 Program Verification & Validation

B. E. Hey

December 19, 1994

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Consequence Analysis
Westinghouse Hanford Company

MASTER

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1.0 PURPOSE

This document summarizes the Verification and Validation (V&V) of the Westinghouse Hanford Company computer code GXQ, Version 4.0 (GXQ). This document fulfills the testing requirements of Section 4.3 "Software Configuration Control" of the *Safety Analysis and Regulation Work Procedures* (WHC 1992). Results of the V&V are contained in Appendix A. This document also provides the mechanism for incorporating record copies of the V&V software documentation into Site Document Control according to the Westinghouse Quality Assurance Manual (WHC 1990).

2.0 DESCRIPTION OF PROGRAM

GXQ computes atmospheric dispersion coefficients (X/Q) using the Gaussian straight line plume model. Site specific joint frequency and population data also can be used to provide site specific acute, chronic, and population weighted X/Q s. Several options are available to the analyst which allow application of various correction factors and frequency criteria. For a more detailed description of GXQ the reader should refer to the *GXQ 4.0 Users' Guide* (Hey 1994). The GXQ source code listing is provided in Appendix A.

3.0 REQUIREMENTS SPECIFICATION

GXQ is written for applications in safety and environmental analyses. The requirements listed in this section are selected commensurate for that level of development. These requirements are generally designed to (1) define the accepted performance levels; and (2) confirm that the code operates properly over the normal range of variables. Documented evidence that these requirements are satisfied demonstrates that GXQ produces correct results when used to analyze problems within a specific domain of applications. This effort is consistent with guidelines for the V&V of existing programs and ANSI/ANS-10.4-1987.

1. Methodologies employed shall produce results demonstrably consistent with modern atmospheric science techniques.
2. Site specific joint frequency and population data shall be used when called for.
3. Maximum flexibility shall be incorporated for selection of various models and correction factors.
4. Execution speed shall be such that several coefficients can be computed within a few seconds.
5. Error checking and warning messages shall be employed to the extent practical.
6. Differences of a few percent or more between computed and benchmark results shall be justified.
7. Coding shall be modular and maintainable to the extent practical.

4.0 VERIFICATION AND VALIDATION

The models employed by GXQ are taken from various atmospheric science literature and computer code documentation. A more thorough discussion of the models and their limits are found in Hey (1994) and the supporting references. The validation of GXQ comes through the use and treatment of these models. The verification of GXQ is obtained by ensuring that the equations making up these models are solved correctly. Several test cases were designed to exercise the various routines and models programmed into GXQ. Verification of GXQ results is obtained either by (1) independent hand or computer-assisted solution of identical or similar models or, (2) by comparison to independent and validated code results performing a similar function. Together, these test cases provide a level of confidence that the code produces correct and valid results when used to analyze problems within the limits of the models selected.

Several test cases were constructed to verify GXQ performance. These test cases are listed in Table 1 along with a short description, and the method and result of verification.

Table 1. GXQ Verification Case Summary

Case Name	Description	Method of Verification	Result
1A	95% Sector (acute)	Compare to GENII	OK
1B	Sector Annual Average (chronic)	Compare to GENII	OK
1C	95% Sector, Population Weighted, 80 km (50-mi), Centerline	Compare to GENII	OK
1D	95% Overall Site (acute)	Hand check of CDF	OK
1E	Overall Site Annual Average (chronic)	Compare to GENII	OK
1F	Overall Site Annual Average, Population Weighted, 80 km (50-mi), Sector Average	Compare to GENII	OK
1G	95% Sector, 61-m (200 ft) Elevated Release	Compare to GENII	OK
1H	50% Sector	Compare to GENII	OK

Table 1 Continued. GXQ Verification Case Summary

Case Name	Description	Method of Verification	Result
2A	By Atmospheric Stability Class and Wind Speed, Ground Level, Centerline, Continuous Release	By hand using GXQ model.	OK
2B1A	Plume depletion, Ground level constant elevation release.	Spreadsheet	OK
2B1B	Plume depletion, 100m stack level constant elevation release.	Spreadsheet	OK
2B1C	Plume depletion, Ground level rising plume.	Spreadsheet	OK
2B1D	Plume depletion, 100m stack level falling plume.	Spreadsheet	OK
2B1E	Plume depletion, Ground level rising plume w/ vertical wind profile.	Spreadsheet	OK
2B1F	Plume depletion, 100m stack level falling plume w/ vertical wind profile.	Spreadsheet	OK
2B2	Graphical comparison of GXQ generated plume depletion factors for a ground level release to those presented in Figure 5.5 of Slade ¹ .	Graphical Comparison	OK
2B3	Graphical comparison of GXQ generated plume depletion factors for an elevated release to those presented in Figure 5.5 of Slade ³ .	Graphical Comparison	OK
2C	Same as 2A but with MACCS Building Wake	Spreadsheet	OK
2D	Same as 2A but with NRC (1982) Plume Meander	Spreadsheet	OK
2E	Same as 2A but with 5th Power Law Plume Meander	By hand	OK
2F	Same as 2A but with Sector Averaging	By hand	OK
2G	Same as 2A but Peak Air Concentration	By hand	OK

¹Slade, D. H., 1968, Meteorology and Atomic Energy, 1968, U.S. Atomic Energy Commission, Office of Information Services, Washington D.C.

Table 1 Continued. GXQ Verification Case Summary

Case Name	Description	Method of Verification	Result
2H1	Same as 2A but with MACCS Plume Rise, Mills Adjustment, Downwash, Gravity Settling, Entrainment, and Wind Adjustment/Iteration	Spreadsheet	OK
2H2A	Same as 2A but with ISC2 Plume Rise w/ $\Delta T = -3.266$ °C (i.e., momentum only)	Spreadsheet	OK
2H2B	Same as 2H2A but w/ $\Delta T = 3$ °C (i.e., unstable-momentum, stable-buoyant)	Spreadsheet	OK
2H2C	Same as 2H2A but w/ $\Delta T = 57$ °C (i.e., buoyancy based on ΔT)	Spreadsheet	OK
2H2D	Same as 2H2A but w/ $q_h = 1.0E+5$ w (i.e., mostly momentum with low heat flux)	Spreadsheet	OK
2H2E	Same as 2H2A but w/ $q_h = 1.0E+6$ w (i.e., buoyancy with low heat flux)	Spreadsheet	OK
2H2F	Same as 2H2A but w/ $q_h = 5.0E+6$ w (i.e., buoyancy with medium heat flux)	Spreadsheet	OK
2H2G	Same as 2H2A but w/ $q_h = 1.0E+7$ w (i.e., buoyancy with high heat flux)	Spreadsheet	OK
2I	Same as 2G but with Flow Rate Adjustment	Spreadsheet	OK
2J	Same as 2A but with source adjustment to simulate evaporation	Spreadsheet	OK
3	Atmospheric Stability Class F with 1 m/s (3.3 ft/s) Wind Speed, Plot File	Hand check of plot file	OK

Results from each of the test cases listed in Table 1 are included in Appendix B. The format for each test case discussed in Appendix B provides for; (1) case discussion and conclusion, (2) independent check results, and (3) GXQ code results. Because execution of GXQ echoes the input file, copies of the input files are included only as necessary. The computer codes and libraries used in this report are listed below.

- GXQ (Version 4, 19-December-94)
- GENII Dose Calculation Program (Version 1.485, 3-Dec-90)
- GENII Default Parameter Values (28-Mar-90, RAP)
- 200 AREA - 10 M - Pasquill A - G (1983 - 1991, Average)
- 200 AREA - 61 M - Pasquill A - G (1983 - 1991, Average)
- Population within 80 km (50 mi) of the Hanford 200 Area, 1990 Census
(Beck, et al. 1991) Created 10/21/91 KR, Revised 2/4/92 KR
- Microsoft EXCEL² (Version 2.0).

²a trademark of Microsoft, Inc.

5.0 CONCLUSION

Based on the acceptable performance of GXQ to the test cases documented in this report, there is every reason to expect that accurate and consistent results can be expected from its use. Therefore, GXQ is suitable for applications in safety and environmental analyses without requiring additional verification or validation of the program for individual analyses. This does not lessen the requirements for an independent review of results produced by GXQ. Good engineering practices dictate that computer-generated results be given a "sanity check," (i.e., compared with measurements or experience, or if possible independently calculated).

6.0 REFERENCES

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APPENDIX A
GXQ SOURCE CODE LISTING

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WHC-SD-GN-SWD-30003 Rev 1

! CHANGE HISTORY:

- ! GXQ12 - base code
- ! GXQ13 - added momentum/buoyancy plume rise model
- ! GXQ14 - added 2nd order effective rel. ht. calculation, deleted chronic mode
- ! GXQ15 - increased size of JF arrays, added v0 to X/Q denominator
- ! GXQ152 - added scaling factor to pop. wt. X/Q, added 5th power law PM
- ! GXQ153 - changed some integer variables to logical variables
- ! GXQ2 - revised code structure to allow joint selection of isite, ipop, ifox
! eliminated population, overall site and interpolation modes
- ! GXQ22 - special compilation to read in w0, drel, qh, fact for M. Medsker
- ! GXQ23 - special compilation to population weight mode 2 X/Q for R. Britton
- ! GXQ24 - corrected execution time calculation and renamed ntot, nsec, nsite
- ! GXQ241 - special compilation to calculate cdf based on histogram
- ! GXQ25 - corrected puff model when volume flow rate non-zero
- ! GXQ251 - added option to select jet or buoyant stack downwash
- ! GXQ252 - special compilation for Mark Medsker
- ! GXQ253 - special compilation for Mark Medsker/Brit Hey
- ! GXQ254 - added more output to debug option and added iflow option
- ! GXQ255 - special compilation for Mark Medsker
- ! GXQ256 - added buoyant plume rise limits, removed isa flag
- ! GXQ257 - revised downwash and plume rise models
- ! GXQ258 - corrected u**3 to u**9 in subroutine rise
! corrected undefined x to xvz in xvz function
! included he in parameter list for dep and simpson subroutines
- ! GXQ259 - added sector frequency output
- ! GXQ26 - revised logical choice echo
! power function eqns. for NRC plume meander
- ! GXQ3 - independent review version
! Plume rise/settling/downwash and vertically corrected wind speed is
! iterated until the change in he is less than 1 m.
! Revised dry dep. integration to start @ 0.1 m and use evenly spaced
! logarithmic intervals and to include fumigation condition.
! Revised flow correction to a correction of sigmay and sigmaz based
! on virtual distance.
! Added option to base buoyancy rise on initial plume density in
! addition to sensible heat emission rate.
! Added lift-off criterion to plume rise
! Revised code to separately track lateral and vertical virtual
! distances. Maximum of flow and building wake chosen.
! Deleted entry of plume vertical velocity. Calculated internally.
! Fref more complicated and added z to receptor input requirements.
! Increased wind speed array size to 9
- ! GXQ31 - Added stability class and wind speed to mode 1 output
! Allowed wind speed adjustment for other than 10 m
! Incorporated NRC RG 1.145 building wake
! Corrected density difference in plume rise based on density
! Limit effective plume height to 0.1 m minimum for depletion calcs.
! Automatic selection of buoyant or momentum dominant downwash
! Deleted ipuff flag and revised code to calculate max. air concentra.
- ! GXQ31A - Added code to make temporary GXQ.TMP file for receptor locations
! This version put on G drive.
- ! GXQ31B - Corrected unit 4 to tmpio in subroutine cdf
! Corrected do loop to calculate sector frequency before testing popt
! Added warning # 11
! Revised sector frequency output to indicate 100% when inorm=t.
! Warning #3 revised
! Correct cdf.out print logic
- ! GXQ31C - Corrected warning #7 logic and to not exit
! Changed warning #3 to only activate when scale .ne. 1.0
! Changed wording of error #22.
! Added error #24.
- ! GXQ4 - Changed stability factors to coincide with MACCS and depend on Tamb
! Set sx3=sy3 to allow for virtual source adjusted sigma x
! Changed system calls and EOF query for Lahey F77L Compiler
! Changed plume density input to temperature input
! Put scaling option in ISRC=1
! Added wind speed power scaling option in ISRC=2
! Removed momentum rise to strictly implement MACCS buoyant plume rise model
! Added ISC2 momentum/buoyancy rise model
! Employ method of Pasquill for air entrainment in rising plume
! Added Mills' modified buoyant rise for open area fires
! Divide overall site annual average to individual X/Q by 16
! Adding Warning #11 to warn against zero stack height plume rise w/o Mills adjustment

! Modified Warning #10 to alert user to entrainment during plume rise
! Eliminated Error #23
! Added Error #23 to prevent divide by zero error.
! Changed logic in 1/5th power law PM to (rd.le.100 hr) as in MACCS
! Changed plume rise code to calculate urel (wind speed at rel. ht.)
! Added Error #29 to prevent hrel > h.
! Fixed error identified by PDF when puff model used and iflow=1.
! Made he a function of x when evaluating integral in depletion factor
! Changed the way overall site X/Q calculated bin frequencies
! Added Error #30 to flag overall site input error
!

! VARIABLE DEFINITIONS:

! drel -release diameter (m)
! dwash -stack downwash (m)
! fact -scaling factor applied to X/Q
! pref -plume trapping reflection parameter
! freq -frequency at which calculated X/Q will be exceeded
! h -mixing height (m) (1000 meters typical)
! hb -building height (m)
! he -effective release height (m)
! ha -reference anemometer height (m)
! hrel -stack or release height (m)
! ichk -debug flag (T to select)
! icdf -print out cdf flag (T to select)
! iclass -atmospheric stability class (1-7 is Pasquil A-G)
! idep -plume depletion flag (1 to select)
! ifox -joint frequency treatment flag (T for frequency to exceed)
! (F for annual average)
! inorm -jf normalization flag (T to select)
! ipm -plume meander (1 to select NRC RG 1.145)
! (2 to select 5th power law)
! isec -sector number (1=S, 2=SSW, etc., if 0 then all 16 sectors)
! isite -overall site (T to select)
! ipop -population weighted (T to select)
! irise -plume rise flag (1 or 2 to select)
! iflow -flow rate adjustment option (1 to select)
! iwake -building wake flag (1 to select)
! iwash -downwash model (0 to turn off)
! (1 to select jet model)
! (2 to select buoyant model)
! iwind -correction to 10m wind speed for higher elevations (1 to select)
! isrc -source term model flag
! mode -operational mode flag of code (1-3)
! nbin -number of stability class and wind speed bins in JF file
! power -power law grid density factor
! qh -convective heat release rate (w)
! rd -release duration (hr)
! t0 -initial plume temperature (C)
! tamb -ambient temperature (C)
! title -problem title
! ua -wind speed at reference anemometer height (m/s)
! ue -effective wind speed (m/s)
! uhe -wind speed at he (m/s)
! uc -critical wind speed preventing lift-off (m/s)
! urel -wind speed at release height (m/s)
! v0 -initial volume flow rate of plume (m3/s)
! vd -deposition velocity (m/s)
! vg -gravitational settling velocity (m/s)
! w0 -initial velocity of plume (m/s)
! wb -building width (m)
! x -distance from release point to receptor (m)
! xint -number of distance intervals for plot file
! xmax -maximum distance for plot file (m)
! xqmin -minimum scaled xq to compute
! y -receptor offset from centerline (m)
! yint -number of offset intervals for plot file
! ymax -maximum offset for plot file (m)
! z -receptor height above ground level (m)
!

! ARRAY DEFINITIONS:

! sjf - joint frequency vector for sector
! xq - X/Q vector corresponding to sjf vector
! ws - wind speed vector corresponding to sjf vector

```

! cl - stability class vector corresponding to sjf vector
! cd - cumulative distribution vector corresponding to sjf vector
! ubin - wind speed vector read from joint frequency file
! jf - joint frequency array for all sectors
! sname - character array of compass sector names
! cname - character array of stability class names
!
program gxq
common /dat5/ p(16,10),dmid(10)
common /dat3/ sjf(0:1008),xq(0:1008),ws(0:1008),cl(0:1008),cd(0:1008),nbin
common /dat2/ ubin(9),jf(63,16),nsbin,nubin,ha
common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
logical ifox,inorm,icdf,ichk,isite,ipop
character*80 title
character*80 line
integer cl
real jf
character*3 sname(16)
character*2 cname(7)
integer stdout,stdin,tmpio,unit4,unit8
data sname/'S ','SSW','SW ','WSW','W ','WNW','NW ','NNW','N '
&,'NNE','NE ','ENE','E ','ESE','SE ','SSE'/
data cname/'A ','B ','C ','D ','E ','F ','G '/
stdin=5
stdout=6
tmpio=2
unit4=4
unit8=8
!
! print header read and echo first portion of standard input file
!
call head(0,stdout)
OPEN(stdin,file='gxq.in',STATUS='OLD',ERR=5)
goto 6
5 print *, 'ERROR #1 - Could not open gxq.in file.'
call exit
6 call input(stdin,stdout,tmpio)
call message
!
! mode is site specific
! read sector and distance from standard input
!
if (mode.eq.1) then
OPEN(unit4,file='gxq.tmp',STATUS='OLD')
call readjf(tmpio)
if(ipop)call readpop(tmpio)
call head(mode,stdout)
if(icdf) then
OPEN(unit8,FILE='CDF.OUT',FORM='FORMATTED',STATUS='UNKNOWN')
call head(0,unit8)
call head(4,unit8)
endif
endif
!
! Prepare for 16 sectors worth of receptor data if overall site selected
!
if(isite)then
nsec=16
else
nsec=1
endif
nall=nbin*nsec
!
! return here if more receptors to calculate
!
126 continue
!
! read receptor location from pre-processed data on unit4
!
popt=0.0

```

```

do 500 k=1,nsec
  read(unit4,*,end=700) isec,xmax,z
!
! fill joint frequency array if first time through read loop
!
  if(k.eq.1)call fill(isec)
!
! calculate single sector xq for each non-zero joint frequency array element
!
  pops=0.0
  do 400 i=1,nbin
    ii=i+(k-1)*nbin
    if(sjf(ii).gt.0.0)then
      if(.not.ipop)then
        call xqsub(xmax,0.0,z,ws(ii),cl(ii),xq(ii))
      else
        xq(ii)=0.0
        do 192 j=1,10
          x=dmid(j)
          if(x.gt.xmax)goto 193
          pop=p(isec,j)
          if(pop.eq.0.0)goto 192
          call xqsub(x,0.0,z,ws(ii),cl(ii),xqp)
          xq(ii)=xq(ii)+xqp*pop
          if(i.eq.1)pops=pops+pop
192      continue
193      continue
        endif
      else
        xq(ii)=0.0
      endif
400    continue
!
! tally total population
!
    popt=popt+pops
500  continue
!
! calculate total sector frequency in percent
!
    sfreq=0.0
    do 600 i=1,nall
      sfreq=sfreq+sjf(i)
600    continue
!
! set population totals to 1 if zero or no population weighting
!
    poptt=popt
    if(poptt.eq.0.0)poptt=1.0
    if(ipop.and.popt.eq.0)then
      xqp=0.0
      index=1
      goto 650
    endif
    if(.not.ipop)popt=1.0
!
! calculate annual average or frequency of exceedance X/Q
!
    if(.not.ifox) then
      xqp=0.0
      do 610 i=1,nall
        xqp=xqp+sjf(i)*xq(i)
610      continue
      if(inorm)xqp=xqp/sfreq*100.
      if(isite.and..not.ipop)xqp=xqp/16.
      xqp=xqp/100.
    else
      call sort(nall)
      call condense(nall,ncond)
      call cdf(ncond,unit8)
      call inter(xqp,freq,ncond,index)
    endif
!

```

```

! write results to standard out
!
650 continue
write(line(1:80),'(80x)')
if(isite)then
write(line(2:4),'(a)') 'ALL'
write(line(9:16),'(i8)') int(xmax)
write(line(18:25),'(i8)') int(z)
else
write(line(2:4),'(a)') sname(isec)
write(line(9:16),'(i8)') int(xmax)
write(line(18:25),'(i8)') int(z)
endif
if(inorm)then
write(line(27:32),'(f6.2)') 100.00
else
write(line(27:32),'(f6.2)') sfreq
endif
write(line(34:43),'(i10)') int(popt)
write(line(45:54),'(1pe10.2)') xqp
write(line(56:65),'(1pe10.2)') xqp/poptt
if(ifox)then
write(line(67:68),'(a)') cname(cl(index))
write(line(74:78),'(f5.2)') ws(index)
endif
write(stdout,'(a)') line
goto 126
700 continue
if(k.ne.1)then
print *, 'ERROR #30 - 16 sectors of data required for overall-site calculation.'
endif
close (unit4,status='delete')
!
! mode is by stability class and wind speed
! read stability class, wind speed, distance and offset from standard input
!
elseif (mode.eq.2) then
call head(mode,stdout)
call comment(stdin,stdout)
710 read(stdin,*,end=140) iclass,ua,x,y,z
call xqsub(x,y,z,ua,iclass,xqp)
write(stdout,1010) cname(iclass),ua,int(x),int(y),int(z),xqp
1010 format(1x,a2,6x,f8.2,2x,3(i8,2x),1pe10.2)
goto 710
140 continue
!
! mode is to make plot file
! read stability class, wind speed, max distance, distance intervals,
! max offset, offset intervals, and min xq from standard input
!
elseif (mode.eq.3) then
call comment(stdin,stdout)
read(stdin,*) iclass,ua,xmax,imax,ymax,jmax,xqmin,power
z=0.0
print *
write(stdout,99) title
99 format(1x,a79)
print *
print *, 'stability class ',cname(iclass)
print *, 'wind speed',ua
print *, 'max distance and intervals',xmax,imax
print *, 'max offset and intervals',ymax,jmax
print *, 'minimum X/Q calculated and power',xqmin,power
xmin=0.0
if(xmax.lt.xmin.or.ymax.lt.0.0) then
print *, 'ERROR #2 - Xmax or ymax less than or equal to zero.'
call exit
endif
call head(mode,stdout)
!
xstp=(xmax-xmin)**(1/power)/imax
ystp=ymax**(1/power)/jmax
write(stdout,1011) 0.0,0.0,0.0

```

```

do 145 j=1,jmax
y=(float(j)*ystp)**power
write(stdout,1011) 0.0,y,0.0
write(stdout,1011) 0.0,-y,0.0
145 continue
do 160 i=1,imax
x=(float(i)*xstp)**power+xmin
y=0.0
call xqsub(x,y,z,ua,iclass,xqp)
xqp=xqp
write(stdout,1011) x,y,xqp
do 150 j=1,jmax
y=(float(j)*ystp)**power
call xqsub(x,y,z,ua,iclass,xqp)
xqp=xqp
write(stdout,1011) x,y,xqp
write(stdout,1011) x,-y,xqp
if(xqp.lt.xqmin)goto 160
1011 format(1x,2(1pe11.3,1x),1pe10.2)
150 continue
160 continue
!
endif
call exit
end
!
! Subroutine to read joint frequency data
!
subroutine readjf(tmpio)
common /dat3/ sjf(0:1008),xq(0:1008),ws(0:1008),cl(0:1008),cd(0:1008),nbin
common /dat2/ ubin(9),jf(63,16),nsbin,nubin,ha
character*80 tit1,tit2
integer cl,tmpio
real jf
OPEN(tmpio,FILE='jointfre.in',STATUS='OLD',err=100)
read(tmpio,9) tit1
read(tmpio,9) tit2
print *
write(*,98) 'JOINT FREQUENCY DATA:
write(*,99) tit1
write(*,99) tit2
read(tmpio,*) nubin,nsbin,ndum,ndum,ha
read(tmpio,*) (ubin(i),i=1,nubin)
nbin=nubin*nsbin
do 10 i=1,nbin
10 read(tmpio,*) (jf(i,j),j=1,16)
9 FORMAT(A80)
98 format(1x,a42)
99 format(1x,a79)
close (tmpio)
return
100 print *, 'ERROR #3 - Could not open jointfre.in file.'
call exit
end
!
! Subroutine to read population data
!
subroutine readpop(tmpio)
common /dat5/ p(16,10),dmid(10)
character*80 tit1,tit2
integer tmpio
OPEN(tmpio,FILE='pop.in',STATUS='OLD',err=100)
read(tmpio,9) tit1
read(tmpio,9) tit2
print *
write(*,98) 'POPULATION DATA:
write(*,99) tit1
write(*,99) tit2
read(tmpio,'()')
do 5 i=1,16
5 read(tmpio,*) (p(i,j),j=1,10)
read(tmpio,'(/////)' )
read(tmpio,*) (dmid(j),j=1,10)

```



```

9   FORMAT(A80)
98  format(1x,a42)
99  format(1x,a79)
    close (tmpio)
    return
100 print *, 'ERROR #4 - Could not open pop.in file.'
    call exit
    end

!
! Subroutine to calculate X/Q
!
    subroutine xqsub(x,y,z,ua,iclass,xq)
    common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
    common /dat2/ ubin(9),jf(63,16),nsbin,nubin,ha
    logical ifox,inorm,icdf,ichk,isite,ipop
    character*80 title
    character*2 cname(7)
    real jf
    data cname/'A ','B ','C ','D ','E ','F ','G '/
! input error check on receptor data
    if (x) 35,35,36
35  print *, 'ERROR #5 - Distance is less than or equal to zero.'
    call exit
36  continue
    if(iclass.lt.1.or.iclass.gt.7)then
        print *, 'ERROR #6 - Stability class must be between 1 and 7.'
    endif
    if(ua.le.0.0)then
        print *, 'ERROR #7 - Wind speed must be greater than zero.'
    endif

!
! ***** EFFECTIVE RELEASE HEIGHT CALCULATIONS *****
!
! function fhe returns effective release height, he, plume height wind speed,
! uhe, and the effective wind speed, ue, which is the average of the wind speed
! at the release height, hrel, and the wind speed at the effective release
! height, he.
! First, calculate wind speed at release height.
!
    urel=ua
    if(iwind.eq.1)urel=ueff(ua,ha,hrel,iclass)
    he=fhe(x,ue,uhe,urel,ua,uc,iclass,hprb,hprm,hprl,fm,fb,hwash,hgrav,w0)

!
! ***** SIGMA CALCULATIONS *****
!
! initialize all sigmas to zero
!
    sx1=0.0
    sy1=0.0
    sz1=0.0
    sx2=0.0
    sy2=0.0
    sz2=0.0
    sx3=0.0
    sy3=0.0
    sz3=0.0
    sy4=0.0
    sx5=0.0
    sy5=0.0
    sz5=0.0

!
! calculate unadjusted sigmas
!
    sy1=sigmay(iclass,x)
    sx1=sy1
    sz1=sigmaz(iclass,x)

!
! calculate flow adjusted sigmas (virtual source method)
!

```

```

if(iffow.eq.1)then
  xv2=xvy(iclass,3600.*urel*rd/2.5066)
  xv2=xvy(iclass,drel/2.5066)
  xv2=xvz(iclass,fref(hrel,z,sz1)*v0/(2.5066*urel*drel))
  sx2=sigmay(iclass,x+xv2)
  sy2=sigmay(iclass,x+xv2)
  sz2=sigmaz(iclass,x+xv2)
endif

!
! calculate building wake adjusted sigmas (MACCS virtual source model)
! NRC RG 1.145 building wake model incorporated in X/Q Calculation below
!
  if(iwake.eq.2)then
    xvy3=xvy(iclass,wb/4.3)
    xvz3=xvz(iclass,hb/2.15)
    sy3=sigmay(iclass,x+xvy3)
    sx3=sy3
    sz3=sigmaz(iclass,x+xvz3)
  endif

!
! calculate sigmay adjusted for plume meander if selected
! ipm=1 for NRC RG 1.145 plume meander model
! ipm=2 for 5th power law plume meander model
! ipm=3 for sector average model
!
  if(ipm.eq.1.and.x.ge.800.)then
    sy4=(pm1(iclass,ue)-1)*sigmay(iclass,800.)*sy1
  elseif(ipm.eq.1.and.x.lt.800.)then
    sy4=pm1(iclass,ue)*sy1
  elseif(ipm.eq.2)then
    sy4=pm2(rd)*sy1
  elseif(ipm.eq.3)then
    sy4=0.15666*x
    sy1=sy4
    sy2=sy4
    sy3=sy4
  endif

!
! adjust sigmas to account for air entrainment in rising plume using
! method of Pasquill
!
  if(ientr.eq.1)then
    tmp=((he-hrel)/3.5)**2
    sy5=sqrt(sy1**2+tmp)
    sz5=sqrt(sz1**2+tmp)
    sx5=sy5
  endif

!
! select maximum of sigmas calculated above
!
  sx=max(sx1,sx2)
  sx=max(sx,sx3)
  sx=max(sx,sx5)
  sy=max(sy1,sy2)
  sy=max(sy,sy3)
  sy=max(sy,sy4)
  sy=max(sy,sy5)
  sz=max(sz1,sz2)
  sz=max(sz,sz3)
  sz=max(sz,sz5)

!
! adjust sigmaz for uniform vertical mixing if conditions appropriate
!
  ifum=0
  if(sz.ge.0.8*h)then
    sz=h/2.5066
    ifum=1
  endif

!
! ***** OFFSET CALCULATIONS *****
!
  if(ipm.eq.3)then
    fy1=1.0

```

```

else
  fy1=fy(y,sy)
endif

if(ifum.eq.1)then
  gz1=1.0
else
  gz1=gz(he,z,sz)
endif

!
! ***** ATMOSPHERIC DISPERSION - X/Q *****
!
  if(iwake.eq.1)then
    ! continuous release with NRC RG 1.145 building wake
    xq1=fy1*gz1/(6.2832*ue*(sy1*sz+wb*hb/6.2832))
    xq2=fy1*gz1/(18.850*ue*sy1*sz)
    xq3=fy1*gz1/(6.2832*ue*sy*sz)
    xq=max(xq1,xq2)
    xq=min(xq,xq3)
  else
    xq=fy1*gz1/(6.2832*ue*sy*sz)
  endif

!
! ***** AIR CONCENTRATION - X/Q *****
!
! calculate transition distance from plume to puff behavior
  xtrans=xvy(iclass,ue*rd*3600./2.5066)-xvx2
  if(ipuff.eq.1)then
    if(iwake.eq.1.or.x.lt.xtrans)then
! plume behavior. Note: NRC model is always continuous release plume
      xq=xq/(rd*3600.)
    else
! puff behavior
      xq=fy1*gz1/(15.750*sx*sy*sz)
    endif
  endif

!
! ***** SCALING *****
!
! determine wind speed scaling factor
  if(isrc.eq.1) then
    sfact=fact
  elseif(isrc.eq.2) then
    sfact=fact*ue**wsexp
  elseif(isrc.eq.3) then
    sfact=fact*10**(ue*wsexp)
  else
    sfact=1.0
  endif

!
! multiply X/Q by plume depletion factor if selected
! limit he to 0.1 for minimum surface roughness
  if(idcp.eq.1) then
    dfact=df(iclass,x,xvzm,urel,ua)
  else
    dfact=1.0
  endif
  xq=xq*sfact*dfact

!
! ***** CHECK PRINT *****
!
  if(ichk) then
    print *, '-----'
    print *, 'atmospheric stability class      ',cname(iclass)
    print *, 'receptor distance                    ',x,' m'
    print *, 'trans. dist. from plume to puff          ',xtrans,' m'
    print *, 'receptor horizontal offset                ',y,' m'
    print *, 'receptor height                          ',z,' m'
    print *, ' '
    print *, 'momentum flux                            ',fm,' m4/s2'
    print *, 'buoyancy flux                            ',fb,' m4/s3'
    print *, 'distance dependent momentum rise          ',hprm,' m'
    print *, 'distance dependent buoyancy rise          ',hprb,' m'
  endif

```

```

print *, 'plume rise limit' =, hprl, ' m'
print *, 'stack downwash' =, hwash, ' m'
print *, 'gravitational settling' =, hgrav, ' m'
print *, 'effective release height (he)' =, he, ' m'
print *, ' '
print *, 'anemometer wind speed' =, ua, ' m/s'
print *, 'wind speed at release height' =, urel, ' m/s'
print *, 'wind speed at he' =, uhe, ' m/s'
print *, 'effective wind speed' =, ue, ' m/s'
print *, 'crit. wind spd. prevent. liftoff=' , uc, ' m/s'
print *, 'initial vertical plume speed' =, w0, ' m/s'
print *, ' '
print *, 'Pasquill sigma y (unadjusted)' =, sy1, ' m'
print *, 'Pasquill sigma z (unadjusted)' =, sz1, ' m'
print *, 'Pasquill sigma x (flow adj.)' =, sx2, ' m'
print *, 'Pasquill sigma y (flow adj.)' =, sy2, ' m'
print *, 'Pasquill sigma z (flow adj.)' =, sz2, ' m'
print *, 'Pasquill sigma y (wake adj.)' =, sy3, ' m'
print *, 'Pasquill sigma z (wake adj.)' =, sz3, ' m'
print *, 'Pasquill sigma y (meander adj.)' =, sy4, ' m'
print *, 'Pasquill sigma y (rise adj.)' =, sy5, ' m'
print *, 'Pasquill sigma z (rise adj.)' =, sz5, ' m'
print *, ' '
print *, 'off-axis horizontal factor' =, fy1
print *, 'plume trapping reflection factor=' , fref(he,z,sz)
print *, 'off-axis vertical factor' =, gz1
print *, 'plume depletion factor' =, dfact
if(isrc.eq.2)then
  print *, 'source term factor' =, sfact, ' mg/s'
else
  print *, 'source term factor' =, sfact
endif
print *, 'atmospheric disper. coeff. (X/Q)=' , xq
endif
return
end

!
! function to determine effective release height and corresponding wind speed
!
function fhe(x,ue,uhe,urel,ua,uc,iclass,hprb,hprm,hprl,fb,hwash,hgrav,w0)
  common /dat2/ ubin(9),jf(63,16),nsbin,nubin,ha
  common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
  logical ifox,inorm,icdf,ichk,isite,ipop
  character*80 title
  real jf
  data pi/3.1415927/
  fhe=hrel
  ue=ua
  uhe=ua
  hrise=0.0
  hwash=0.0
  hgrav=0.0
  hprm=0.0
  hprb=0.0
  hprl=0.0
  fb=0.0
  w0=4.0*v0/(pi*drel*drel)

!
! iterate on effective release height to account for plume rise and
! gravitational settling if selected
!
  do 100 i=1,5
    fheold=fhe
    if(irise.eq.1)hrise=hmaccs(x,ue,ua,uc,iclass,hprb,hprm,hprl,fb,w0)
    if(irise.eq.2)hrise= hisc2(x,ue,ua,uc,iclass,hprb,hprm,hprl,fb,w0)
    if(iwash.eq.1)hwash=dwash(urel,w0)
    if(igrav.eq.1)hgrav=vg*x/ue
! calculate new effective release height
    fhe=hrel+hrise-hgrav-hwash

```

```

! limit effective release height between ground and height of mixing layer
fhe=max(0.0,fhe)
fhe=min(h,fhe)
!
! calculate wind speed at adjusted effective release
! height if measured height is 10 meters and effective release height
! greater than 10 meters.
!
      if(iwind.eq.1)uhe=ueff(ua,ha,fhe,iclass)
!
! calculate average wind speed between ground and effective release height
!
      ue=(uhe+urel)/2.0
!
! exit loop if last calculation of effective release height changed by less
! than 1 meter
!
      if(abs(fhe-fheold).lt.1.0)goto 101
100  continue
101  continue
      return
      end
!
! function to return the xq horizontal correction term
!
      function fy(y,sy)
      fy=exp(-(y/sy)**2)/2.0
      return
      end
!
! function to return the xq vertical correction term
!
      function gz(he,z,sz)
      gz=fref(he,z,sz)*exp(-(((z-he)/sz)**2)/2.0)
      return
      end
!
! function to return the plume trapping reflection factor
!
      function fref(he,z,sz)
      common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
      logical ifox,inorm,icdf,ichk,isite,ipop
      character*80 title
      sz2=sz*sz
      fref=0.0
      err=0.01
      do 10 n=1,5
      fold=fref
      hn=h*n
      val=exp(2.0*(he-hn)*( hn-z)/sz2)+exp(2.0*hn*( he-hn-z)/sz2)+
& exp(2.0*(he+hn)*(-hn-z)/sz2)+exp(2.0*hn*(-he-hn+z)/sz2)
      fref=fref+val
      if(abs(fref-fold).lt.err)goto 20
10    continue
20    fref=1.0+exp(-(2.0*z*he)/sz2)+fref
      return
      end
!
! Function to return effective wind speed at altitude z
! Ref. Hanna page 32 (rural roughness)
!
      function ueff(ua,ha,he,iclass)
      dimension p(7)
      data p/.07,.07,.1,.15,.35,.55,.60/
      helim=min(he,200.)
      helim=max(helim,10.)
      ueff=ua*(helim/ha)**p(iclass)
      return
      end

```

```

!
! Function sigmay determines sy given distance
!
      function sigmay(iclass,x)
      dimension ay(7)
      data ay/.3658,.2751,.2089,.1471,.1046,.0722,.0481/
      sigmay=ay(iclass)*x**0.9031
      return
      end

!
! Function xvy determines distance given sy
!
      function xvy(iclass,sy)
      dimension ay(7)
      data ay/.3658,.2751,.2089,.1471,.1046,.0722,.0481/
      xvy=(sy/ay(iclass))**(1/.9031)
      return
      end

!
! Function sigmaz determines sz given distance
!
      function sigmaz(iclass,x)
      dimension az1(7),az2(7),az3(7),bz1(7),bz2(7),bz3(7),cz2(7),cz3(7)
      data az1/.192,.156,.116,.079,.063,.053,.032/
      data az2/.00066,.0382,.113,.222,.211,.086,.052/
      data az3/.00024,.055,.113,1.26,6.73,18.05,10.83/
      data bz1/.936,.922,.905,.881,.871,.814,.814/
      data bz2/1.941,1.149,.911,.725,.678,.74,.74/
      data bz3/2.094,1.098,.911,.516,.305,.18,.18/
      data cz2/9.27,3.3,.0,-1.7,-1.3,-.35,-.21/
      data cz3/-9.6,2.,.0,-13.,-34.,-48.6,-29.2/
      if (x.lt.100.) then
      sigmaz=az1(iclass)*x**bz1(iclass)
      elseif (x.le.1000.) then
      sigmaz=az2(iclass)*x**bz2(iclass)+cz2(iclass)
      else
      sigmaz=az3(iclass)*x**bz3(iclass)+cz3(iclass)
      endif
      return
      end

!
! Function xvx determines distance given sz
!
      function xvx(iclass,sz)
      dimension az1(7),az2(7),az3(7),bz1(7),bz2(7),bz3(7),cz2(7),cz3(7)
      data az1/.192,.156,.116,.079,.063,.053,.032/
      data az2/.00066,.0382,.113,.222,.211,.086,.052/
      data az3/.00024,.055,.113,1.26,6.73,18.05,10.83/
      data bz1/.936,.922,.905,.881,.871,.814,.814/
      data bz2/1.941,1.149,.911,.725,.678,.74,.74/
      data bz3/2.094,1.098,.911,.516,.305,.18,.18/
      data cz2/9.27,3.3,.0,-1.7,-1.3,-.35,-.21/
      data cz3/-9.6,2.,.0,-13.,-34.,-48.6,-29.2/
      xvx=(sz/az1(iclass))**(1/bz1(iclass))
      if (xvx.lt.100.) return
      xvx=((sz-cz2(iclass))/az2(iclass))**(1/bz2(iclass))
      if (xvx.lt.1000.) return
      xvx=((sz-cz3(iclass))/az3(iclass))**(1/bz3(iclass))
      return
      end

!
! Subroutine to fill joint frequency, wind speed and class vectors given
! sector isec. All sectors are filled if isite=.true.
!
      subroutine fill(isec)
      common /dat3/ sjf(0:1008),xq(0:1008),ws(0:1008),cl(0:1008),cd(0:1008),nbin
      common /dat2/ ubin(9),jf(63,16),nsbin,nubin,ha
      common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
      &tamb,t0,v0,drel,fact,wsexp,
      &mode,ifox,inorm,icdf,ichk,isite,ipop,
      &iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
      &idep,isrc,ipuff,iwind
      logical ifox,inorm,icdf,ichk,isite,ipop

```

```

character*80 title
integer cl
real jf
if(isite)then
  do 200 k=1,16
    j=0
    do 100 i=1,nbin
      ii=i+(k-1)*nbin
      sjf(ii)=jf(i,k)
      ws(ii)=ubin((i-1)/nsbin+1)
      j=j+1
      if (j.gt.nsbin) j=1
      cl(ii)=j
100    continue
200  continue
  else
    do 300 i=1,nbin
      sjf(i)=jf(i,iseq)
      ws(i)=ubin((i-1)/nsbin+1)
      j=j+1
      if (j.gt.nsbin) j=1
      cl(i)=j
300  continue
  endif
  return
end

!
! Subroutine to sort xq and corresponding sjf, cl and ws vectors in
!   descending X/Q order.
!
subroutine sort(n)
common /dat3/ sjf(0:1008),xq(0:1008),ws(0:1008),cl(0:1008),cd(0:1008),nbin
integer cl
do 20 ii=1,n
  rmax=xq(ii)
  imax=ii
  do 10 i=ii+1,n
    if (rmax.lt.xq(i)) then
      rmax=xq(i)
      imax=i
    endif
10  continue
!
  t=xq(ii)
  xq(ii)=xq(imax)
  xq(imax)=t
!
  t=sjf(ii)
  sjf(ii)=sjf(imax)
  sjf(imax)=t
!
  t=ws(ii)
  ws(ii)=ws(imax)
  ws(imax)=t
!
  t=cl(ii)
  cl(ii)=cl(imax)
  cl(imax)=t
!
20  continue
  return
end

!
! Subroutine to condense equal X/Qs into a single bin
! n - current length of array
! m - condensed length of array
!
subroutine condense(n,m)
common /dat3/ sjf(0:1008),xq(0:1008),ws(0:1008),cl(0:1008),cd(0:1008),nbin
integer cl
m=n
do 20 ii=2,n
  xx=xq(ii-1)

```

```

5  continue
   if(xx.eq.xq(ii))then
     sjf(ii-1)=sjf(ii-1)+sjf(ii)
     m=m-1
     do 10 i=ii,m
       xq(i)=xq(i+1)
       sjf(i)=sjf(i+1)
       ws(i)=ws(i+1)
       cl(i)=cl(i+1)
10  continue
     if(ii.eq.m)return
     goto 5
   elseif(ii.eq.m-1)then
     return
   endif
20  continue
   end

!
! Subroutine cdf creates a cumulative distribution out of vector sjf
! and normalizes if inorm=.true.
!
   subroutine cdf(n,unit8)
     common /dat3/ sjf(0:1008),xq(0:1008),ws(0:1008),cl(0:1008),cd(0:1008),nbin
     common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
     &tamb,t0,v0,drel,fact,wsexp,
     &mode,ifox,inorm,icdf,ichk,isite,ipop,
     &iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
     &idep,iscr,ipuff,iwind
     logical ifox,inorm,icdf,ichk,isite,ipop
     character*80 title
     integer cl,unit8
     character*2 cname(7)
     data cname/'A ','B ','C ','D ','E ','F ','G '/
     cd(0)=0.0
     sjf(0)=0.0
     do 10 i=1,n
       cd(i)=cd(i-1)+(sjf(i)+sjf(i-1))/2.0
10  continue
     if(.not.inorm)goto 30
     t=cd(n)/100.
     do 20 i=1,n
       cd(i)=cd(i)/t
20  continue
30  continue

     if(icdf)then
       write(unit8,98)
       do 50 i=1,n
         write(unit8,99) cname(cl(i)),ws(i),sjf(i),cd(i),xq(i)
50  format(1x)
98  format(17x,a2,5x,2(f5.2,1x),f6.2,1x,1pe10.2)
99  format(17x,a2,5x,2(f5.2,1x),f6.2,1x,1pe10.2)
       endif
       return
     end

!
! Subroutine inter interpolates xqp based on freq
!
   subroutine inter(xqp,freq,n,index)
     common /dat3/ sjf(0:1008),xq(0:1008),ws(0:1008),cl(0:1008),cd(0:1008),nbin
     integer cl
     if (freq.gt.cd(n)) then
       print *
       print *,'ERROR #8 - Selected frequency above joint freq. range.'
       print *,'          Selected frequency is      ',freq
       print *,'          Maximum sector frequency is',cd(n)
       call exit
     endif
     if (freq.lt.cd(1)) then
       print *
       print *,'WARNING #1 - Selected frequency is below minimum available.'
       print *,'          Selected frequency is      ',freq
       print *,'          Minimum cumulative frequency is',cd(1)
       print *,'          X/Q below set equal to value corresponding'

```



```

print *, '          to minimum cumulative frequency.'
xqp=xq(1)
index=1
return
endif
do 10 i=2,n
if (freq.lt.cd(i)) then
  xqp=(freq-cd(i-1))/(cd(i)-cd(i-1))*(xq(i)-xq(i-1))+xq(i-1)
!   return index whose xq is closest to interpolated value
  index=i
  if((xq(i-1)-xqp).lt.(xqp-xq(i)))index=i-1
  return
endif
10 continue
end

! Calculate plume meander correction factor as given by NRC R.G. 1.145
!
function pm1(iclass,u)
pm1=1.0
if(iclass .lt. 4 .or. u .ge. 6.0) return
select case(iclass)
case(4)
  pm1=2.
case(5)
  pm1=3.
case(6)
  pm1=4.
case(7)
  pm1=6.
end select
if(u.lt.2.0) return
pm1=(u/6)**(-log(pm1)/1.0986)
return
end

! Calculate 5th power law plume meander correction factor
!
function pm2(rd)
tb=10./60.
t1=10./60.
t2=1.0
t3=100.0

if(rd.lt.t1.or.rd.gt.t3)then
print *, 'WARNING #2 - Release duration outside validity of One-fifth'
print *, '          Power Law. Release duration must be'
print *, '          between 10 min. and 100 hrs.'
endif

if(rd.le.t2)then
  alpha=0.2
else
  alpha=0.25
endif
pm2=(rd/tb)**alpha
return
end

! Subroutine to print out input options selected and warning messages
!
subroutine message
common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
logical ifox,inorm,icdf,ichk,isite,ipop
character*80 title
print *
print *, 'MODE:'
if (mode.eq.1)then
print *, 'Site specific X/Q calculated.'

```

```

elseif(mode.eq.2)then
print *, 'X/Q calculated by stability class and wind speed.'
elseif(mode.eq.3)then
print *, 'Plot file of distance, offset and X/Q created.'
else
print *, 'ERROR #9 - Invalid mode specified.'
endif

print *
print *, 'LOGICAL CHOICES:'
if(mode.eq.1)then
  if(ifox)then
    print *, 'Joint frequency used to calculate X/Q based on frequency of exceedance.'
  else
    print *, 'Joint frequency used to calculate annual average X/Q.'
  endif

  if(inorm)then
    print *, 'Joint frequency data normalized.'
  else
    print *, 'No normalization of joint frequency.'
  endif

  if(icdf)then
    print *, 'Cumulative distribution contained in file CDF.OUT.'
  endif

  if(isite)then
    print *, 'X/Q calculated for overall site.'
  else
    print *, 'X/Q calculated for single sector.'
  endif

  if(ipop)then
    print *, 'X/Q is population weighted.'
  endif
endif

if(ichk)then
print *, 'X/Q parameter print option selected.'
endif

print *
print *, 'MODELS SELECTED:'
if(iflow.eq.1)then
  print *, 'Flow adjustment model.'
elseif(iflow.ne.0)then
  print *, 'ERROR #16 - Invalid flow rate adjustment model selected.'
  call exit
endif

if(iwake.eq.1)then
  print *, 'NRC RG 1.145 building wake model selected.'
elseif(iwake.eq.2)then
  print *, 'MACCS Virtual source building wake model selected.'
elseif(iwake.ne.0)then
  print *, 'ERROR #11 - Invalid building wake model selected.'
  call exit
endif

if(ipm.eq.1)then
  print *, 'NRC RG 1.145 plume meander model selected.'
elseif(ipm.eq.2)then
  print *, '5th power law plume meander model selected.'
elseif(ipm.eq.3)then
  print *, 'Sector average model selected.'
elseif(ipm.ne.0)then
  print *, 'ERROR #12 - Invalid plume meander model selected.'
  call exit
endif

if(ientr.eq.1)then
  print *, 'Plume rise air entrainment model selected.'

```

```

elseif(ientr.ne.0)then
  print *, 'ERROR #28 - Invalid plume rise air entrainment model selected.'
  call exit
endif

if(irise.eq.1)then
  if(qh.ne.0.0)then
    print *, 'MACCS buoyancy plume rise model based on convective heat.'
  else
    print *, 'MACCS buoyancy plume rise model based on temperature difference.'
  endif
elseif(irise.eq.2)then
  if(qh.ne.0.0)then
    print *, 'ISC2 momentum/buoyancy plume model based on convective heat.'
  else
    print *, 'ISC2 momentum/buoyancy plume model based on temperature difference.'
  endif
elseif(irise.ne.0)then
  print *, 'ERROR #13 - Invalid plume rise model selected.'
  call exit
endif

if(irise.ne.0.and.igrnd.eq.1)then
  print *, 'Mills buoyant rise modification for pool fire selected.'
endif
if(igrnd.ne.0.and.igrnd.ne.1)then
  print *, 'ERROR #27 - Invalid ground effect model selected.'
  call exit
endif

if(irise.ne.0.and.iwash.eq.1)then
  print *, 'Stack downwash model selected.'
endif
if(iwash.ne.0.and.iwash.ne.1)then
  print *, 'ERROR #15 - Invalid downwash model selected.'
  call exit
endif

if(igrav.eq.1)then
  print *, 'Gravitational settling model selected.'
elseif(igrav.ne.0)then
  print *, 'ERROR #14 - Invalid gravitational settling model selected.'
  call exit
endif

if(iddep.eq.1)then
  print *, 'Source depletion model selected.'
elseif(iddep.ne.0)then
  print *, 'ERROR #10 - Invalid plume depletion model selected.'
  call exit
endif

if(isrc.eq.1)then
  print *, 'X/Q adjusted by scaling factor.'
elseif(isrc.eq.2)then
  print *, 'X/Q adjusted for wind speed dependent source term (c u^a).'
elseif(isrc.eq.3)then
  print *, 'X/Q adjusted for wind speed dependent source term (c 10^au).'
elseif(isrc.ne.0)then
  print *, 'ERROR #25 - Invalid source adjustment model selected.'
  call exit
endif

if(ipuff.eq.1)then
  print *, 'Gaussian puff model selected.'
else
  print *, 'Default Gaussian plume model selected.'
endif

if(iwind.eq.1)then
  print *, 'Wind velocity corrected for average plume height.'
elseif(iwind.ne.0)then
  print *, 'ERROR #17 - Invalid wind adjustment model selected.'

```

```

    call exit
endif

print *
print *, 'WARNING/ERROR MESSAGES:'
if(isrc.ne.0.and.fact.ne.1.0)then
print *, 'WARNING #3 - Scaled X/Q units do not reflect the user specified scaling factor.'
endif

if(mode.eq.1.and..not.ifox.and.ipm.ne.3)then
print *, 'WARNING #4 - Annual average X/Q is normally sector averaged.'
endif

if(iwake.eq.1.and.iflow.ne.0)then
print *, 'WARNING #5 - NRC RG 1.145 building wake model may not'
print *, '        be compatible with plume flow adjustment.'
endif

if(mode.eq.1.and.ipop.and.ipm.ne.3)then
print *, 'WARNING #6 - Population weighted X/Q is normally sector'
print *, '        averaged to simulate uniform distribution.'
endif

if(((ipm.eq.1.or.ipm.eq.2).or.(ipm.eq.3.and..not.ipop)).and.ipuff.eq.1)then
print *, 'WARNING #7 - Maximum normalized air concentration may'
print *, '        be underestimated with plume meander on.'
endif

! if(irise.ne.0.and.idep.ne.0)then
! print *, 'WARNING #8 - Plume depletion may be underestimated if plume is rising.'
! endif

! if(igrav.ne.0.and.idep.ne.0)then
! print *, 'WARNING #9 - Plume depletion may be overestimated if plume is falling.'
! endif

if(irise.ne.0.and.ientr.eq.0)then
print *, 'WARNING #10 - X/Q may be underestimated for plume rise scenario without'
print *, '        accounting for entrainment.'
endif

if(irise.ne.0.and.hrel.eq.0.and.igrnd.ne.1)then
print *, 'WARNING #11 - Effective plume rise from ground level may be overestimated'
print *, '        using Briggs plume rise model for stacks. Consider Mills'
print *, '        modification.'
endif

if(irise.eq.2.and.v0.le.0.0)then
print *, 'ERROR #18 - Momentum rise requires non-zero initial vertical plume flow rate (v0).'
call exit
endif

if(irise.ne.0.and.drel.le.0.0)then
print *, 'ERROR #19 - Plume rise requires non-zero release diameter (d).'
call exit
endif

if(iwash.ne.0.and.drel.le.0.0)then
print *, 'ERROR #20 - Stack down wash requires non-zero release diameter (d).'
call exit
endif

if(iflow.ne.0.and.drel.le.0.0)then
print *, 'ERROR #21 - Flow adjustment requires non-zero release diameter (d).'
call exit
endif

if(isrc.eq.2.and.ipuff.eq.1)then
print *, 'ERROR #26 - Evaporation model inconsistent with puff source.'
call exit
endif

if(iwake.eq.1.and.ipuff.eq.1.and.rd.eq.0)then

```

```
print *, 'ERROR #23 - Puff model requires non-zero release duration.'  
call exit  
endif
```

```
if(hrel.gt.h)then  
print *, 'ERROR #29 - Code does not handle releases above mixing layer.'  
call exit  
endif
```

```
return  
end
```

```
! Subroutine head prints output headers  
  
      subroutine head(n,i)  
common /dat1/ title,hrel,h,freq,vd,vg,w,b,hb,r,d,qh,  
&tamb,t0,v0,drel,fact,wsexp,  
&mode,ifax,inorm,icdf,ichk,isite,ipop,  
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,  
&idep,isrc,puff,iwind  
logical ifox,inorm,icdf,ichk,isite,ipop  
character*80 title  
character*80 line  
character*11 ctime  
character*8 cdate  
if(n.eq.0)then  
write(i,900)  
format(  
&/'  
&/'  
&/'          GXQ Version 4.0  
&/'        December 19, 1994  
&/'  
&/' '  
&' General Purpose Atmospheric Dispersion Code  
&' Produced by Radiological & Toxicological Analysis  
&' Westinghouse Hanford Company  
&' '  
&' Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 1.  
&' Validation documented in WHC-SD-GN-SWD-3003 Rev. 1.  
&' Code Custodian is Brit E. Hey, WHC, ext. 376-2921.  
&/')  
call date(cdate)  
call time(ctime)  
write(i,990)cdate  
format(1x,'Run Date = ',a8)  
write(i,991)ctime  
format(1x,'Run Time = ',a11)
```

```
elseif(n.eq.1)then  
write(i,'(/')  
write(i,91) title  
write(i,'(/')  
write(i,91)  
  
           TOTAL       AVERAGE  
write(i,91)                POPULATION INDIVIDUAL  
  
write(i,91)                  RECEPT   SECT.             SCALED     SCALED    ATM.   WIND  
write(i,91)              DISTANCE HEIGHT FREQ.            X/Q       X/Q      STAB. SPEED  
  
write(line(1:79),'(a)' ) 'SECTOR   (m)         (m) (%)  POPULATION (s/m3)   (s/m3) CLASS (m/s)
```

```
if(ipuff.eq.1)then  
write(line(46:52),'(a)' ) '(1/m3) '  
write(line(57:63),'(a)' ) '(1/m3) '  
elseif(isrc.eq.2)then  
write(line(46:52),'(a)' ) '  
write(line(57:63),'(a)' ) '  
endif  
write(i,91) line  
write(i,91)
```

```

elseif(n.eq.2)then
write(i,'(/)')
write(i,91) title
write(i,'(/)')
write(i,91)
      'ATM.    WIND                                RECEPTOR    SCALED
write(i,91)
      'STAB.    SPEED    DISTANCE    OFFSET    HEIGHT    X/Q
write(line(1:79),'(a)') 'CLASS    (m/s)    (m)    (m)    (m)    (s/m3)

if(ipuff.eq.1)then
  write(line(51:57),'(a)') '(1/m3) '
elseif(isrc.eq.2)then
  write(line(51:57),'(a)') ' '
endif
write(i,91) line
write(i,91)
      '_____

elseif(n.eq.3)then
write(i,'(/)')
write(i,91) title
write(i,'(/)')
write(i,91)
      '
write(i,91)
      '    DISTANCE    OFFSET    SCALED
write(line(1:35),'(a)') '    (m)    (m)    X/Q
if(ipuff.eq.1)then
  write(line(28:34),'(a)') '(1/m3) '
elseif(isrc.eq.2)then
  write(line(28:34),'(a)') ' '
endif
write(i,91) line
write(i,91)
      '_____

elseif(n.eq.4)then
write(i,'(/)')
write(i,91)'CUMULATIVE DISTRIBUTION
write(i,'(/)')
write(i,91)
      '
      '    ATM.    WIND    SECT.    CUM.    SCALED
write(i,91)
      '    DISTANCE    STAB.    SPEED    FREQ.    FREQ.    X/Q
write(line(1:79),'(a)') 'SECTOR    (m)    CLASS    (m/s)    (%)    (%)    (s/m3)

if(ipuff.eq.1)then
  write(line(44:50),'(a)') '(1/m3) '
elseif(isrc.eq.2)then
  write(line(44:50),'(a)') ' '
endif
write(i,91) line
write(i,91)
      '_____
endif

90  format('1')
91  format(1x,a)
return
end

!
! calculate plume depletion as given by Meteorology and Atomic Energy (1968)
!
function df(iclass,x,xvzm,urel,ua)
common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mde,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,isrc,ipuff,iwind
logical ifox,inorm,icdf,ichk,isite,ipop
character*80 title
data xstp,xmin,imax/5.0,0.1,10/
! imax must be even
df=1.0
val=0.0
if(x.le.xmin)return
x1=xmin

```

```

do 160 i=1,10
  x2=x1*xstp
  if(x2.gt.x)x2=x
  val=val+simpson(iclass,xvzm,x1,x2,imax,urel,ua)
  if(x2.eq.x)goto 170
  x1=x2
160 continue

170 continue
  df=exp(-vd/2.5066*val)
  return
end

!
! perform 1/3 rule simpson integration
!
  function simpson(iclass,xvzm,a,b,n,urel,ua)
    d=(b-a)/n
    val=0.0
    do 10 j=2,n-2,2
      val=val+4.*f(iclass,d*(j-1)+a,xvzm,urel,ua)+2.*f(iclass,d*j+a,xvzm,urel,ua)
10    continue
    val=f(iclass,a,xvzm,urel,ua)+val+4.*f(iclass,d*(n-1)+a,xvzm,urel,ua)+f(iclass,d*n+a,xvzm,urel,ua)
    simpson=val*(b-a)/(3.*n)
    return
  end

!
! plume depletion function to be integrated
!
  function f(iclass,x,xvzm,urel,ua)
    sz=sigmaz(iclass,x*xvzm)
    he=fhe(x,ue,uhe,urel,ua,uc,iclass,hprb,hprm,hprl,fm,fb,hwash,hgrav,w0)
    he=max(0.1,he)
    f=gz(he,0.0,sz)/(sz*uhe)
    return
  end

!
! read and echo input data
!
  subroutine input(stdin,stdout,unit4)
    common /dat2/ ubin(9),jf(63,16),nsbin,nubin,ha
    common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
    &tamb,t0,v0,drel,fact,wsexp,
    &mode,ifox,inorm,icdf,ichk,isite,ipop,
    &iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
    &idep,iscr,ipuff,iwind
    logical ifox,inorm,icdf,ichk,isite,ipop
    character*80 title
    real jf
    integer stdin,stdout,unit4
    write(stdout,'(//)')
    write(stdout,98)
98    format(1x,'INPUT ECHO:')
    read(stdin,9) title
9    FORMAT(A80)
    write(stdout,99) title
99    format(1x,a79)
    call comment(stdin,stdout)
    read(stdin,*) mode
    write(stdout,91) mode
    call comment(stdin,stdout)
    read(stdin,*) ifox,inorm,icdf,ichk,isite,ipop
    write(stdout,92) ifox,inorm,icdf,ichk,isite,ipop
    call comment(stdin,stdout)
    read(stdin,*) ipuff,idep,iscr,iwind
    write(stdout,93) ipuff,idep,iscr,iwind
    call comment(stdin,stdout)
    read(stdin,*) iwake,ipm,iflow,ientr
    write(stdout,93) iwake,ipm,iflow,ientr
    call comment(stdin,stdout)
    read(stdin,*) irise,igrnd,iwash,igrav
    write(stdout,93) irise,igrnd,iwash,igrav
91    format(5x,i1)
92    format(5x,12(11,5x))

```

```

93  format(5x,12(i1,5x))
    call comment(stdln,stdout)
    read(stdln,*) hrel,ha,h,freq
    write (stdout,1000) hrel,ha,h,freq
    call comment(stdln,stdout)
    read(stdln,*) wb,hb,rd,vd,vg
    write (stdout,1000) wb,hb,rd,vd,vg
    call comment(stdln,stdout)
    read(stdln,*) tamb,t0,v0,drel,qh
    write (stdout,1000) tamb,t0,v0,drel,qh
    call comment(stdln,stdout)
    read(stdln,*) fact,wsexp
    write (stdout,1000) fact,wsexp
    call comment(stdln,stdout)
1000 format(3x,6(1p13.5,2x))
!
! Unit changes
!
    tamb=tamb+273.0
    t0=t0+273.0
!
! For mode 1 allow zero entries as input shortcut meaning all sectors
!
    if(mode.eq.1)then
        OPEN(unit4,file='gxq.tmp',STATUS='UNKNOWN')
100    read(stdln,*,err=102,end=200) isec,xmax,z
        GOTO 104
102    print *,'ERROR #24 - GXQ encountered an error reading the receptor location data.'
        print *,'      Most likely this is caused by a carriage return after the last line.'
        call exit
104    CONTINUE
        if(isec.lt.0.or.isec.gt.16)then
            print *,'ERROR #22 - Sector must be an integer from 0 to 16.'
            call exit
        endif
        if(isec.eq.0)then
            do 110 i=1,16
110        write(unit4,*) i,xmax,z
            else
                write(unit4,*) isec,xmax,z
            endif
        goto 100
200    continue
        close (unit4)
        endif
        return
        end
!
! print and skip over comment lines
!
        subroutine comment(stdln,stdout)
            integer stdln,stdout
            character*80 dummy
12        read(stdln,9) dummy
9        FORMAT(A80)
            if(dummy(1:1).ne.'c'.and.dummy(1:1).ne.'C') goto 13
            write(stdout,99) dummy
99        format(1x,a79)
            goto 12
13        backspace(stdln)
            return
            end
!
! MACCS plume rise model
!
! References:
!
! Randerson, D., ed., 1984, Atmospheric Science and Power Production,
! DE84-005177, U.S. Department of Energy, Washington, DC., p. 334-339.
!
! NRC, 1977, Methods for Estimating Atmospheric Transport and Dispersion
! of Gaseous Effluents in Routine Releases from Light-Water-Cooled
! Reactors, NRC Regulatory Guide 1.111, Washington, DC.

```



```

!
! MACCS Users' Manual page 2-7
!
function hmaccs(x,ue,ua,uc,iclass,hprb,hprm,hprl,fm,fb,w0)
common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
&tamb,t0,v0,drel,fact,wsexp,
&mode,ifox,inorm,icdf,ichk,isite,ipop,
&iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
&idep,iscr,ipuff,iwind
logical ifox,inorm,icdf,ichk,isite,ipop
character*80 title
data g,betab/9.807,0.6/
!
! initial plume temperature difference
dt=t0-tamb
sp=s(iclass,tamb)
hprb=0.0
hprm=0.0
hprl=0.0
hmaccs=0.0
fm=0.0
!
! buoyancy flux (based on convective heat flux or temperature difference)
if(qh.le.0.0)then
fb=g*w0*drel**2*dt/(4.0*t0)
else
fb=0.002575*qh/tamb
endif
if(fb.le.0.0)return

! lift-off criterion
uc=9999.0
if(hb.gt.0.0.and.hrel.le.hb)then
uc=(9.09*fb/hb)**0.33333
if(ua.ge.uc)return
endif

! Briggs buoyancy plume rise
select case(iclass)
! Buoyancy rise in unstable and neutral conditions
case(1:4)
hprb=1.6*fb**0.33333*x**0.666667/ue
! limit buoyant plume rise as recommended by Briggs
hprl1=((300.0*fb)/ue**3)
hprl2=(1.94E+7*fb/(betab*betab*ue))**0.33333
hprl=min(hprl1,hprl2)
! Buoyancy rise in stable conditions
case(5:7)
hprb=1.6*fb**0.33333*x**0.666667/ue
hprl=2.6*(fb/(ue*sp))**0.33333
end select
hprb=min(hprb,hprl)
!
! employ Mills modification for buoyant rise from a burning pool if selected
if(igrnd.eq.1)then
r=drel/(2*betab)
hmaccs=(hprb**3+r**3)**0.33333-r
else
hmaccs=hprb
endif
hmaccs=max(hmaccs,0.0)
return
end
!
! Stability parameter function
!
function s(iclass,tamb)
data g/9.8/
select case(iclass)
case(5)
s=g/tamb*(0.005+0.0098)
case(6)
s=g/tamb*(0.0275+0.0098)

```

```

case(7)
  s=g/tamb*(0.0625+0.0098)
end select
return
end

!
!
!
! Stack downwash function
!
  function dwash(urel,w0)
    common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
    &tamb,t0,v0,drel,fact,wsexp,
    &mode,ifox,inorm,icdf,ichk,isite,ipop,
    &iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
    &idep,isrc,ipuff,iwind
    logical ifox,inorm,icdf,ichk,isite,ipop
    character*80 title
    data g/9.807/

! buoyancy flux (based on convective heat or temperature difference)
    if(qh.le.0.0)then
      dt=t0-tamb
      fb=g*w0*drel**2*dt/(4.0*t0)
    else
      fb=0.002575*qh/tamb
    endif
    fb=max(fb,0.0)

!
    r1=w0/urel
    if(fb.gt.0.0)then
      r2=0.45*w0*(drel/(2.0*fb))**0.333333
    else
      r2=0.0
    endif
    rvel=max(r1,r2)
    rvel=max(rvel,0.0)

!
    if(rvel.lt.1.5)then
      dwash=2*(1.5-rvel)*drel
    else
      dwash=0.0
    endif
    return
  end

!
!
!
! ISC2 plume rise model
!
  function hisc2(x,ue,ua,uc,iclass,hprb,hprm,hprl,fb,w0)
    common /dat1/ title,hrel,h,freq,vd,vg,wb,hb,rd,qh,
    &tamb,t0,v0,drel,fact,wsexp,
    &mode,ifox,inorm,icdf,ichk,isite,ipop,
    &iflow,iwake,ipm,ientr,irise,igrnd,iwash,igrav,
    &idep,isrc,ipuff,iwind
    logical ifox,inorm,icdf,ichk,isite,ipop
    character*80 title
    data pi,g/3.1415926,9.807/

! initial plume temperature difference
    dt=t0-tamb
    sp=s(iclass,tamb)
    hprb=0.0
    hprm=0.0

! momentum flux
    fm=w0**2*drel**2*tamb/(4.0*t0)

! buoyancy flux (based on convective heat or temperature difference)
    if(qh.le.0.0)then
      fb=g*w0*drel**2*dt/(4.0*t0)
    else

```

```

    fb=0.002575*qh/tamb
  endif
  fb=max(fb,0.0)
!
! unstable or neutral - crossover between momentum and buoyancy
  select case(iclass)
  case(1:4)
    if(fb.lt.55.0)then
      dtc=0.0297*t0*(w0/(drel*drel))**0.333333
    else
      dtc=0.00575*t0*(w0*w0/drel)**0.333333
    endif
!
! unstable or neutral - buoyancy rise
    if(dt.ge.dtc.and.t0.gt.tamb)then
      if(fb.lt.55.0)then
        xf=49.0*fb**0.625
        hprl=21.425*fb**0.75/ue
      else
        xf=119.0*fb**0.4
        hprl=38.71*fb**0.6/ue
      endif
      hprb=hprl
      if(x.lt.xf)then
        hprb=1.6*fb**0.333333*x**0.666667/ue
        hprb=min(hprb,hprl)
      endif
!
! lift-off criterion
      uc=9999.0
      if(hb.gt.0.0.and.hrel.le.hb)then
        uc=(9.09*fb/hb)**0.333333
        if(ua.ge.uc)then
          hprb=0.0
          hprl=0.0
        endif
      endif
!
! unstable or neutral - momentum rise
    else
      if(fb.le.55.0)then
        xmax=49.0*fb**0.625
      else
        xmax=119.0*fb**0.4
      endif
      temp=4.0*drel*(w0+3.0*ue)**2/(w0*ue)
      xmax=max(temp,xmax)
      xl=min(x,xmax)
      bj=0.333333+ue/w0
      hprm=(3.0*fm*xl/(bj*ue)**2)**0.333333
      hprl=3.0*drel*w0/ue
      hprm=min(hprm,hprl)
    endif
!
! stable - crossover between momentum and buoyancy
  case(5:7)
    dtc=0.019582*t0*w0*sqrt(sp)
!
! stable - buoyancy rise
    if(dt.ge.dtc.and.t0.gt.tamb)then
      xf=2.0715*w0/sqrt(sp)
      hprl=2.6*(fb/(ue*sp))**0.333333
      hprb=hprl
      if(x.lt.xf)then
        hprb=1.6*fb**0.333333*x**0.666667/ue
        hprb=min(hprb,hprl)
      endif
!
! lift-off criterion
      uc=9999.0
      if(hb.gt.0.0.and.hrel.le.hb)then
        uc=(9.09*fb/hb)**0.333333
        if(ua.ge.uc)then

```

```

        hprb=0.0
        hprl=0.0
      endif
    endif
!
! stable - momentum rise
  else
    xmax=0.5*pi*ue/sqrt(sp)
    xl=min(x,xmax)
    bj=0.333333+ue/w0
    hprm=(3.0*fm*sin(xl*sqrt(sp)/ue)/(bj**2*ue*sqrt(sp)))*0.333333
    hprm1=1.5*(fm/(ue*sqrt(sp)))*0.333333
    hprm2=3.0*drel*w0/ue
    hprl=min(hprm1,hprm2)
    hprm=min(hprm,hprl)
  endif
end select
hisc2=hprm+hprb

! employ Mills modification for buoyant rise from a burning pool if selected
if(igrnd.eq.1)then
  r=drel/1.2
  hisc2=(hisc2**3+r**3)*0.333333-r
endif
return
end
!
! terminate program
!
  subroutine exit
  close(2)
  close(3)
  close(4)
  close(5)
  close(8)
  stop
end

```

APPENDIX B
GXQ VERIFICATION CASES

Case 1A: 95% Sector (acute)

Discussion and Conclusion

This case tests the ability of GXQ to calculate a Hanford Site specific atmospheric dispersion coefficients (X/Q) for an acute release. Meteorological conditions are chosen such that the X/Q is exceeded 5% of the time for the given sector in the 200 Area. The model and treatment used is similar to that employed by the GENII program. The results are within 1%, attributed mostly to roundoff. A GENII input file is not included because it is easily reproduced from the information given in the GXQ output file. The GXQ output file for this case follows.

WHC-SD-GN-SWD-30003 Rev 1

Current Input File Name: 1a.IN

GXQ Version 4.0
December 19, 1994

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 1.
Code Custodian is Brit E. Hey, WHC, ext. 376-2921.

Run Date = 02/02/95
Run Time = 15:36:21.85

INPUT ECHO:

VV Case 1A: 95% Sector Normalized X/Q (Acute)

c mode
1

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
T T F F F F

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 0

c PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)
0.00000E+00	1.00000E+01	1.00000E+03	5.00000E+00

initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
0.00000E+00	0.00000E+00	0.00000E+00	1.00000E-03	1.00000E-03

ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (W)
2.00000E+01	2.20000E+01	1.00000E+00	1.00000E+00	0.00000E+00

X/Q scaling factor (?)	Wind Speed Exponent
1.00000E+00	7.80000E-01

c RECEPTOR DEPENDENT DATA (no line limit)

MODE:

Site specific X/Q calculated.

LOGICAL CHOICES:

Joint frequency used to calculate X/Q based on frequency of exceedance.

Joint frequency data normalized.

X/Q calculated for single sector.

MODELS SELECTED:

Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA - 10 M - Pasquill A - F (1983 - 1987 Average)

Created 10-Mar-88 RAP

VV Case 1A: 95% Sector Normalized X/Q (Acute)

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION	AVERAGE INDIVIDUAL	ATM. STAB. CLASS	WIND SPEED (m/s)
					SCALED X/Q (s/m ³)	SCALED X/Q (s/m ³)		
S	100	0	100.00	1	2.87E-02	2.87E-02	F	0.89
SSW	100	0	100.00	1	2.60E-02	2.60E-02	F	0.89
SW	100	0	100.00	1	2.89E-02	2.89E-02	F	0.89
WSW	100	0	100.00	1	3.09E-02	3.09E-02	F	0.89
W	100	0	100.00	1	3.09E-02	3.09E-02	F	0.89
WNW	100	0	100.00	1	3.33E-02	3.33E-02	F	0.89
NW	100	0	100.00	1	3.01E-02	3.01E-02	F	0.89
NNW	100	0	100.00	1	3.10E-02	3.10E-02	F	0.89
N	100	0	100.00	1	3.33E-02	3.33E-02	F	0.89
NNE	100	0	100.00	1	3.20E-02	3.20E-02	F	0.89
NE	100	0	100.00	1	2.88E-02	2.88E-02	F	0.89
ENE	100	0	100.00	1	2.33E-02	2.33E-02	E	0.89
E	100	0	100.00	1	2.33E-02	2.33E-02	E	0.89
ESE	100	0	100.00	1	1.54E-02	1.54E-02	E	0.89
SE	100	0	100.00	1	1.50E-02	1.50E-02	E	0.89
SSE	100	0	100.00	1	2.77E-02	2.77E-02	F	0.89
S	12000	0	100.00	1	1.71E-05	1.71E-05	F	0.89
SSW	12000	0	100.00	1	1.53E-05	1.53E-05	F	0.89
SW	12000	0	100.00	1	1.72E-05	1.72E-05	F	0.89
WSW	12000	0	100.00	1	1.85E-05	1.85E-05	F	0.89
W	12000	0	100.00	1	1.85E-05	1.85E-05	F	0.89
WNW	12000	0	100.00	1	2.00E-05	2.00E-05	F	0.89
NW	12000	0	100.00	1	1.80E-05	1.80E-05	F	0.89
NNW	12000	0	100.00	1	1.86E-05	1.86E-05	F	0.89
N	12000	0	100.00	1	2.01E-05	2.01E-05	F	0.89
NNE	12000	0	100.00	1	1.92E-05	1.92E-05	F	0.89
NE	12000	0	100.00	1	1.71E-05	1.71E-05	F	0.89
ENE	12000	0	100.00	1	1.36E-05	1.36E-05	E	0.89
E	12000	0	100.00	1	1.36E-05	1.36E-05	E	0.89
ESE	12000	0	100.00	1	8.48E-06	8.48E-06	E	0.89
SE	12000	0	100.00	1	8.32E-06	8.32E-06	E	0.89
SSE	12000	0	100.00	1	1.64E-05	1.64E-05	F	0.89

Case 1B: Sector Annual Average (chronic)

Discussion and Conclusion

This case tests the ability of GXQ to calculate a Hanford Site specific X/Q for a chronic release. Meteorological conditions are chosen such that the X/Q is the annual average for the 200 Area. The model and treatment used is similar to that employed by the GENII program. The results are within 1%, attributed mostly to roundoff. A GENII input file is not included because it is easily reproduced from the information given in the GXQ output file. The GXQ output file for this case follows.

Current Input File Name: 1b.IN

GXQ Version 4.0
December 19, 1994

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 1.
Code Custodian is Brit E. Hey, WHC, ext. 376-2921.

Run Date = 02/02/95
Run Time = 15:36:24.60

INPUT ECHO:

VV Case 1B: Sector Annual Average X/Q (Chronic)

c mode
1

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F F F F

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 3 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 0

c

c PARAMETER INPUT:

reference release height (m)	anemometer height (m)	mixing height (m)	frequency to exceed (%)
0.00000E+00	1.00000E+01	1.00000E+03	5.00000E+00

c

initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
0.00000E+00	0.00000E+00	0.00000E+00	1.00000E-03	1.00000E-03

c

ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (w)
2.00000E+01	2.20000E+01	1.00000E+00	1.00000E+00	0.00000E+00

c

X/Q scaling factor (?)	Wind Speed Exponent
1.00000E+00	7.80000E-01

c

c RECEPTOR DEPENDENT DATA (no line limit)

MODE:

Site specific X/Q calculated.

WHC-SD-GN-SWD-30003 Rev 1

LOGICAL CHOICES:

Joint frequency used to calculate annual average X/Q.
No normalization of joint frequency.
X/Q calculated for single sector.

MODELS SELECTED:

Sector average model selected.
Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA - 10 M - Pasquill A - F (1983 - 1987 Average)
Created 10-Mar-88 RAP

VV Case 1B: Sector Annual Average X/Q (Chronic)

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION	AVERAGE INDIVIDUAL	ATM. STAB. CLASS	WIND SPEED (m/s)
					SCALED X/Q (s/m3)	SCALED X/Q (s/m3)		
S	100	0	6.05	1	1.67E-04	1.67E-04		
SSW	100	0	3.58	1	9.46E-05	9.46E-05		
SW	100	0	2.72	1	7.88E-05	7.88E-05		
WSW	100	0	2.36	1	7.12E-05	7.12E-05		
W	100	0	3.47	1	1.13E-04	1.13E-04		
WNW	100	0	3.39	1	1.19E-04	1.19E-04		
NW	100	0	3.84	1	1.23E-04	1.23E-04		
NNW	100	0	3.40	1	1.06E-04	1.06E-04		
N	100	0	4.24	1	1.37E-04	1.37E-04		
NNE	100	0	3.85	1	1.07E-04	1.07E-04		
NE	100	0	5.70	1	1.37E-04	1.37E-04		
ENE	100	0	8.05	1	1.97E-04	1.97E-04		
E	100	0	12.82	1	3.43E-04	3.43E-04		
ESE	100	0	15.55	1	3.50E-04	3.50E-04		
SE	100	0	14.34	1	2.88E-04	2.88E-04		
SSE	100	0	6.54	1	1.77E-04	1.77E-04		
S	12000	0	6.05	1	4.85E-08	4.85E-08		
SSW	12000	0	3.58	1	2.64E-08	2.64E-08		
SW	12000	0	2.72	1	2.21E-08	2.21E-08		
WSW	12000	0	2.36	1	2.05E-08	2.05E-08		
W	12000	0	3.47	1	3.34E-08	3.34E-08		
WNW	12000	0	3.39	1	3.63E-08	3.63E-08		
NW	12000	0	3.84	1	3.86E-08	3.86E-08		
NNW	12000	0	3.40	1	3.42E-08	3.42E-08		
N	12000	0	4.24	1	4.52E-08	4.52E-08		
NNE	12000	0	3.85	1	3.56E-08	3.56E-08		
NE	12000	0	5.70	1	4.58E-08	4.58E-08		
ENE	12000	0	8.05	1	6.70E-08	6.70E-08		
E	12000	0	12.82	1	1.17E-07	1.17E-07		
ESE	12000	0	15.55	1	1.17E-07	1.17E-07		
SE	12000	0	14.34	1	9.21E-08	9.21E-08		
SSE	12000	0	6.54	1	5.47E-08	5.47E-08		

Case 1C: 95% Sector, Population Weighted, 80.5 km (50 mi), Centerline

Discussion and Conclusion

This case tests the ability of GXQ to calculate a Hanford Site specific population weighted X/Q for an acute release. Meteorological conditions are chosen such that the X/Q is exceeded 5% of the time for the given sector. The model and treatment used is similar to that employed by the GENII program. The results are exact. A GENII input file is not included because it is easily reproduced from the information given in the GXQ output file. The GXQ output file for this case follows.

WHC-SD-GN-SWD-30003 Rev 1

Current Input File Name: 1c.IN

GXQ Version 4.0
December 19, 1994

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 1.
Code Custodian is Brit E. Hey, WHC, ext. 376-2921.

Run Date = 02/02/95
Run Time = 15:36:27.18

INPUT ECHO:

VV Case 1C: 95% Sector Normalized Population Weighted X/Q (Acute)

c mode
1

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
T T F F F T

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 0

c PARAMETER INPUT:

c release	reference		frequency
c height	anemometer	mixing	to
c (m)	height	height	exceed
	(m)	(m)	(%)
0.00000E+00	1.00000E+01	1.00000E+03	5.00000E+00

c initial	initial		deposition	gravitational
c plume	plume	release	velocity	settling
c width	height	duration	(m/s)	velocity
c (m)	(m)	(hr)	(m/s)	(m/s)
0.00000E+00	0.00000E+00	0.00000E+00	1.00000E-03	1.00000E-03

c ambient	initial	initial	release	convective
c temperature	plume	plume	diameter	heat release
c (C)	temperature	flow rate	(m)	rate(1)
	(C)	(m3/s)		(w)
2.00000E+01	2.20000E+01	1.00000E+00	1.00000E+00	0.00000E+00

c X/Q	
c scaling	Wind
c factor	Speed
c (?)	Exponent
1.00000E+00	7.80000E-01

c RECEPTOR DEPENDENT DATA (no line limit)

MODE:

Site specific X/Q calculated.

LOGICAL CHOICES:

Joint frequency used to calculate X/Q based on frequency of exceedance.

Joint frequency data normalized.

X/Q calculated for single sector.

X/Q is population weighted.

MODELS SELECTED:

Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

WARNING #6 - Population weighted X/Q is normally sector averaged to simulate uniform distribution.

JOINT FREQUENCY DATA:

200 AREA - 10 M - Pasquill A - F (1983 - 1987 Average)

Created 10-Mar-88 RAP

POPULATION DATA:

Population within 80 km of the Hanford 200 Area, 1990 Census (Beck, et al 1991)

Created 10/21/91 KR, Revised 2/4/92 KR

VV Case 1C: 95% Sector Normalized Population Weighted X/Q (Acute)

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION	AVERAGE INDIVIDUAL	ATM. STAB. CLASS	WIND SPEED (m/s)
					SCALED X/Q (s/m3)	SCALED X/Q (s/m3)		
S	80000	0	100.00	5845	2.92E-02	4.99E-06	F	0.89
SSW	80000	0	100.00	13937	4.75E-02	3.41E-06	F	0.89
SW	80000	0	100.00	22666	8.87E-02	3.91E-06	F	0.89
WSW	80000	0	100.00	31223	9.85E-02	3.15E-06	F	0.89
W	80000	0	100.00	102538	2.22E-01	2.16E-06	F	0.89
WNW	80000	0	100.00	5292	1.92E-02	3.63E-06	F	0.89
NW	80000	0	100.00	2879	1.08E-02	3.76E-06	F	0.89
NNW	80000	0	100.00	7308	2.07E-02	2.83E-06	F	0.89
N	80000	0	100.00	4643	1.58E-02	3.39E-06	F	0.89
NNE	80000	0	100.00	24085	5.92E-02	2.46E-06	F	0.89
NE	80000	0	100.00	10372	3.54E-02	3.41E-06	F	0.89
ENE	80000	0	100.00	3956	1.02E-02	2.59E-06	E	0.89
E	80000	0	100.00	3992	1.05E-02	2.63E-06	E	0.89
ESE	80000	0	100.00	3000	4.85E-03	1.62E-06	E	0.89
SE	80000	0	100.00	114734	1.51E-01	1.32E-06	E	0.89
SSE	80000	0	100.00	19390	6.58E-02	3.40E-06	F	0.89

Case 1D: 95% Overall Site (acute)

Discussion and Conclusion

This case tests the ability of GXQ to calculate an overall Hanford Site 200 Area X/Q for an acute release. Meteorological conditions are chosen such that the X/Q is exceeded 5% of the time regardless of wind direction. The GENII program currently in use is not designed to perform this calculation; therefore, the results are checked by hand. Because the ability of GXQ to calculate correct X/Q's for a given atmospheric stability class and wind speed is amply verified in the preceeding and proceeding cases, only the unique feature is verified. The unique feature in this case is the ability of GXQ to construct a cumulative distribution from all 16 sectors of the joint frequency file and to use this distribution to select the appropriate X/Q. To aid this check, the cumulative distribution was written to file and hand checked. Results of the check indicate GXQ is performing this operation correctly. Because of the excessive length of the cumulative distribution files, they are not attached. The GXQ output file for this case follows.

Table 1D. Hand Check of Case 1D Cumulative Distribution
Partial Joint Frequency File

200 AREA - 10 M - Pasquill A - F (1983 - 1987 Average)
Created 10-Mar-88 RAP

	8	6	1	1	10.0										
	.89	2.65	4.7	7.15	9.8	12.7	15.6	19.0							
A	0.33	0.29	0.31	0.21	0.28	0.22	0.12	0.10	0.12	0.08	0.06	0.07	0.10	0.09	0.16
B	0.16	0.11	0.10	0.09	0.11	0.06	0.05	0.03	0.05	0.03	0.02	0.02	0.06	0.05	0.04
C	0.17	0.13	0.10	0.07	0.10	0.07	0.08	0.04	0.02	0.02	0.02	0.03	0.05	0.04	0.07
D	0.95	0.62	0.52	0.41	0.68	0.69	0.56	0.39	0.44	0.26	0.26	0.38	0.58	0.61	0.67
E	0.41	0.19	0.18	0.19	0.33	0.33	0.34	0.31	0.39	0.27	0.35	0.38	0.57	0.56	0.48
F	0.37	0.19	0.17	0.17	0.24	0.30	0.25	0.24	0.38	0.31	0.36	0.37	0.60	0.50	0.40
	1.03	0.50	0.39	0.41	0.58	0.51	0.47	0.40	0.38	0.27	0.34	0.30	0.34	0.37	0.68
	0.30	0.16	0.11	0.12	0.13	0.13	0.09	0.08	0.10	0.06	0.09	0.06	0.08	0.19	0.28
	0.22	0.09	0.07	0.07	0.10	0.06	0.10	0.05	0.07	0.05	0.06	0.05	0.06	0.11	0.21
	0.69	0.37	0.24	0.30	0.37	0.33	0.46	0.30	0.39	0.27	0.30	0.36	0.95	1.48	1.68
	0.33	0.11	0.08	0.08	0.21	0.30	0.35	0.39	0.47	0.30	0.44	0.99	2.24	1.95	1.28
	0.21	0.11	0.06	0.06	0.19	0.20	0.51	0.41	0.59	0.57	0.81	1.63	2.95	2.51	1.64

Calculation of Cumulative Frequencies Starting with Class F 0.89 m/s (i.e. Maximum X/Q)

$$\begin{aligned}
 cf_1 &= 0.5(0.37) = 0.185 \\
 cf_2 &= cf_1 + 0.5(0.37 + 0.19) = 0.465 \\
 cf_3 &= cf_2 + 0.5(0.19 + 0.17) = 0.645 \\
 cf_4 &= cf_3 + 0.5(0.17 + 0.17) = 0.815 \\
 &\text{etc.}
 \end{aligned}$$

Total sum of joint frequencies is 99.9. After normalization of the above calculated cumulative frequencies, they agree exactly with those calculated by GXQ.

WHC-SD-GN-SWD-30003 Rev 1

Current Input File Name: 1d.IN

GXQ Version 4.0
December 19, 1994

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 1.
Code Custodian is Brit E. Hey, WHC, ext. 376-2921.

Run Date = 02/02/95
Run Time = 15:36:30.04

INPUT ECHO:

VV Case 1D: 95% Overall Site (Acute)

c mode
1

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
T F F F T F

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 0

c

c PARAMETER INPUT:

c	release	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)
c	0.00000E+00	1.00000E+01	1.00000E+03	5.00000E+00

c

c	initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
c	0.00000E+00	0.00000E+00	0.00000E+00	1.00000E-03	1.00000E-03

c

c	ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (W)
c	2.00000E+01	2.20000E+01	1.00000E+00	1.00000E+00	0.00000E+00

c

c	X/Q scaling factor (?)	Wind Speed Exponent
c	1.00000E+00	7.80000E-01

c

c RECEPTOR DEPENDENT DATA (no line limit)

MODE:

Site specific X/Q calculated.

LOGICAL CHOICES:

Joint frequency used to calculate X/Q based on frequency of exceedance.
 No normalization of joint frequency.
 X/Q calculated for overall site.

MODELS SELECTED:

Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA - 10 M - Pasquill A - F (1983 - 1987 Average)
 Created 10-Mar-88 RAP

VV Case 1D: 95% Overall Site (Acute)

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION	AVERAGE INDIVIDUAL	ATM. STAB. CLASS	WIND SPEED (m/s)
					SCALED X/Q (s/m3)	SCALED X/Q (s/m3)		
ALL	100	0	99.90	1	2.61E-02	2.61E-02	F	0.89
ALL	12000	0	99.90	1	1.54E-05	1.54E-05	F	0.89

Case 1E: Overall Site Annual Average (chronic)

Discussion and Conclusion

This case tests the ability of GXQ to calculate an overall Hanford Site 200 Area X/Q for a chronic release. Meteorological conditions are chosen such that the X/Q is the annual average for the 200 Area for all wind directions. The model and treatment used is similar to that employed by the GENII program when performing a chronic population weighted X/Q calculation, except that the population is zero in all but the desired distance interval. This was accomplished by editing the POP.IN file used by GENII so that the first distance interval contained a population of 1 in each sector. The remaining distance intervals contained 0 in all sectors. Additionally, the DEFAULT.IN file used by GENII was edited so that the first midpoint distance specified was the desired distance. Since this hypothetical receptor represents 16 individuals (one in each sector), the GXQ X/Q is automatically divided by 16 to provide an overall site annual average applied to an individual. The results between GXQ and GENII are within 1%, attributed mostly to roundoff. A GENII input file is not included because it is easily reproduced from the information given above and in the GXQ output file. The GXQ output file for this case follows.

Current Input File Name: 1e.IN

GXQ Version 4.0
December 19, 1994

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 1.
Code Custodian is Brit E. Hey, WHC, ext. 376-2921.

Run Date = 02/02/95
Run Time = 15:36:36.02

INPUT ECHO:

VV Case 1E: Overall Site Annual Average X/Q (Chronic)

c mode

1

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F F T F

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 3 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 0

c

c PARAMETER INPUT:

c	release	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)
c	0.00000E+00	1.00000E+01	1.00000E+03	5.00000E+00
c	initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)
c	0.00000E+00	0.00000E+00	0.00000E+00	1.00000E-03
c	ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	convective heat release rate(1) (w)
c	2.00000E+01	2.20000E+01	1.00000E+00	0.00000E+00
c	X/Q scaling factor (?)	Wind Speed Exponent		
c	1.00000E+00	7.80000E-01		

c

c RECEPTOR DEPENDENT DATA (no line limit)

MODE:

Site specific X/Q calculated.

LOGICAL CHOICES:

Joint frequency used to calculate annual average X/Q.

No normalization of joint frequency.

X/Q calculated for overall site.

MODELS SELECTED:

Sector average model selected.

Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA - 10 M - Pasquill A - F (1983 - 1987 Average)

Created 10-Mar-88 RAP

VV Case 1E: Overall Site Annual Average X/Q (Chronic)

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION	AVERAGE INDIVIDUAL	ATM. STAB. CLASS	WIND SPEED (m/s)
					SCALED X/Q (s/m3)	SCALED X/Q (s/m3)		
ALL	100	0	99.90	1	1.63E-04	1.63E-04		
ALL	12000	0	99.90	1	5.22E-08	5.22E-08		

**Case 1F: Overall Site Annual Average, Population Weighted, 80 km (50 mi),
Sector Average**

Discussion and Conclusion

This case tests the ability of GXQ to calculate an overall Hanford Site 200 Area population weighted X/Q for a chronic release. The population within 80 km of the 200 Area (1990 Census) is used. Meteorological conditions are chosen such that the X/Q is the annual average, regardless of wind direction. The model and treatment used is similar to that employed by the GENII program. The results are within 1%, attributed mostly to roundoff. A GENII input file is not included because it is easily reproduced from the information given in the GXQ output file. The GXQ output file for this case follows.

WHC-SD-GN-SWD-30003 Rev 1

Current Input File Name: 1f.IN

GXQ Version 4.0
December 19, 1994

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 1.
Code Custodian is Brit E. Hey, WHC, ext. 376-2921.

Run Date = 02/02/95
Run Time = 15:36:38.55

INPUT ECHO:

VV Case 1F: Overall Site 50 Mile Population Weighted X/Q (Chronic)

c mode
1

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F F T T

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 3 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 0

c PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)
0.00000E+00	1.00000E+01	1.00000E+03	5.00000E+00

initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
0.00000E+00	0.00000E+00	0.00000E+00	1.00000E-03	1.00000E-03

ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (W)
2.00000E+01	2.20000E+01	1.00000E+00	1.00000E+00	0.00000E+00

X/Q scaling factor (?)	Wind Speed Exponent
1.00000E+00	7.80000E-01

c RECEPTOR DEPENDENT DATA (no line limit)

MODE:

Site specific X/Q calculated.

LOGICAL CHOICES:

Joint frequency used to calculate annual average X/Q.
 No normalization of joint frequency.
 X/Q calculated for overall site.
 X/Q is population weighted.

MODELS SELECTED:

Sector average model selected.
 Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA - 10 M - Pasquill A - F (1983 - 1987 Average)
 Created 10-Mar-88 RAP

POPULATION DATA:

Population within 80 km of the Hanford 200 Area, 1990 Census (Beck, et al 1991)
 Created 10/21/91 KR, Revised 2/4/92 KR

VV Case 1F: Overall Site 50 Mile Population Weighted X/Q (Chronic)

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m ³)	AVERAGE INDIVIDUAL SCALED X/Q (s/m ³)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	80000	0	99.90	375860	2.77E-03	7.38E-09		

Case 1G: 95% Sector, 61 Meter Elevated Release

Discussion and Conclusion

This case tests the ability of GXQ to calculate a Hanford Site specific X/Q for an acute elevated release. Meteorological conditions are chosen such that the X/Q is exceeded 5% of the time for the given sector. The model and treatment used is similar to that employed by the GENII program. The results are within 1%, attributed mostly to roundoff. A GENII input file is not included since it is easily reproduced from the information given in the GXQ output file. The GXQ output file for this case follows.

WHC-SD-GN-SWD-30003 Rev 1

Current Input File Name: 1g.1N

GXQ Version 4.0
December 19, 1994

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 1.
Code Custodian is Brit E. Hey, WHC, ext. 376-2921.

Run Date = 02/02/95
Run Time = 15:36:41.57

INPUT ECHO:

VV Case 1G: 95% Sector Normalized Elevated X/Q (Acute)

c mode
1

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
T T F F F F

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 0

c PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)
6.10000E+01	6.10000E+01	1.00000E+03	5.00000E+00

initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
0.00000E+00	0.00000E+00	0.00000E+00	1.00000E-03	1.00000E-03

ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (w)
2.00000E+01	2.20000E+01	1.00000E+00	1.00000E+00	0.00000E+00

X/Q scaling factor (?)	Wind Speed Exponent
1.00000E+00	7.80000E-01

c RECEPTOR DEPENDENT DATA (no line limit)

MODE:

Site specific X/Q calculated.

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LOGICAL CHOICES:

Joint frequency used to calculate X/Q based on frequency of exceedance.
Joint frequency data normalized.
X/Q calculated for single sector.

MODELS SELECTED:

Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA - 61 M - Pasquill A - F (1983 - 1987 Average)
Created 10-Mar-88 RAP

VV Case 1G: 95% Sector Normalized Elevated X/Q (Acute)

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION	AVERAGE INDIVIDUAL	ATM. STAB. CLASS	WIND SPEED (m/s)
					SCALED X/Q (s/m3)	SCALED X/Q (s/m3)		
S	100	0	100.00	1	1.01E-07	1.01E-07	A	0.89
SSW	100	0	100.00	1	1.10E-07	1.10E-07	A	0.89

WARNING #1 - Selected frequency is below minimum available.

Selected frequency is 5.00000

Minimum cumulative frequency is 5.78358

X/Q below set equal to value corresponding
to minimum cumulative frequency.

SW	100	0	100.00	1	1.19E-07	1.19E-07	A	0.89
WSW	100	0	100.00	1	1.14E-07	1.14E-07	A	0.89
W	100	0	100.00	1	1.10E-07	1.10E-07	A	0.89
WNW	100	0	100.00	1	1.06E-07	1.06E-07	A	0.89
NW	100	0	100.00	1	8.57E-08	8.57E-08	A	0.89
NNW	100	0	100.00	1	7.96E-08	7.96E-08	A	2.65
N	100	0	100.00	1	6.87E-08	6.87E-08	A	2.65
NNE	100	0	100.00	1	3.99E-08	3.99E-08	A	2.65
NE	100	0	100.00	1	3.59E-08	3.59E-08	A	2.65
ENE	100	0	100.00	1	2.85E-08	2.85E-08	A	4.70
E	100	0	100.00	1	2.01E-08	2.01E-08	A	4.70
ESE	100	0	100.00	1	1.62E-08	1.62E-08	A	7.15
SE	100	0	100.00	1	3.22E-08	3.22E-08	A	2.65
SSE	100	0	100.00	1	7.21E-08	7.21E-08	A	2.65
S	12000	0	100.00	1	7.55E-06	7.55E-06	E	0.89
SSW	12000	0	100.00	1	7.37E-06	7.37E-06	E	0.89
SW	12000	0	100.00	1	7.85E-06	7.85E-06	E	0.89
WSW	12000	0	100.00	1	8.04E-06	8.04E-06	E	0.89
W	12000	0	100.00	1	8.78E-06	8.78E-06	F	0.89
WNW	12000	0	100.00	1	8.58E-06	8.58E-06	F	0.89
NW	12000	0	100.00	1	8.95E-06	8.95E-06	F	0.89
NNW	12000	0	100.00	1	9.05E-06	9.05E-06	F	0.89
N	12000	0	100.00	1	8.93E-06	8.93E-06	F	0.89
NNE	12000	0	100.00	1	8.49E-06	8.49E-06	F	0.89
NE	12000	0	100.00	1	7.69E-06	7.69E-06	E	0.89
ENE	12000	0	100.00	1	6.70E-06	6.70E-06	E	0.89
E	12000	0	100.00	1	6.96E-06	6.96E-06	E	0.89
ESE	12000	0	100.00	1	5.59E-06	5.59E-06	E	0.89
SE	12000	0	100.00	1	5.68E-06	5.68E-06	E	0.89
SSE	12000	0	100.00	1	7.69E-06	7.69E-06	E	0.89

Case 1H: 50% Sector

Discussion and Conclusion

This case tests the ability of GXQ to calculate a Hanford Site specific X/Q for an acute release. Meteorological conditions are chosen such that the X/Q is exceeded 50% of the time for the given sector. The model and treatment used is similar to that employed by the GENII program. The results are within 1%, attributed mostly to roundoff. A GENII input file is not included since it is easily reproduced from the information given in the GXQ output file. The GXQ output file for this case follows.

WHC-SD-GN-SWD-30003 Rev 1

Current Input File Name: 1h.IN

GXQ Version 4.0
December 19, 1994

General-Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 1.
Code Custodian is Brit E. Hey, WHC, ext. 376-2921.

Run Date = 02/02/95
Run Time = 15:36:44.76

INPUT ECHO:

VV Case 1h: 50% Sector Normalized X/Q (Acute)

c mode
1

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
T T F F F F

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 0

c PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)	
0.00000E+00	1.00000E+01	1.00000E+03	5.00000E+01	
initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
0.00000E+00	0.00000E+00	0.00000E+00	1.00000E-03	1.00000E-03
ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (w)
2.00000E+01	2.20000E+01	1.00000E+00	1.00000E+00	0.00000E+00
X/Q scaling factor (?)	Wind Speed Exponent			
1.00000E+00	7.80000E-01			

c RECEPTOR DEPENDENT DATA (no line limit)

MODE:

Site specific X/Q calculated.

WHC-SD-GN-SWD-30003 Rev 1

LOGICAL CHOICES:

Joint frequency used to calculate X/Q based on frequency of exceedance.
Joint frequency data normalized.
X/Q calculated for single sector.

MODELS SELECTED:

Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA - 10 M - Pasquill A - F (1983 - 1987 Average)
Created 10-Mar-88 RAP

VV Case 1H: 50% Sector Normalized X/Q (Acute)

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION	AVERAGE INDIVIDUAL	ATM. STAB. CLASS	WIND SPEED (m/s)
					SCALED X/Q (s/m ³)	SCALED X/Q (s/m ³)		
S	100	0	100.00	1	2.50E-03	2.50E-03	D	2.65
SSW	100	0	100.00	1	1.89E-03	1.89E-03	E	7.15
SW	100	0	100.00	1	2.23E-03	2.23E-03	E	7.15
WSW	100	0	100.00	1	2.66E-03	2.66E-03	D	2.65
W	100	0	100.00	1	3.29E-03	3.29E-03	C	0.89
WNW	100	0	100.00	1	5.10E-03	5.10E-03	E	2.65
NW	100	0	100.00	1	5.29E-03	5.29E-03	E	2.65
NNW	100	0	100.00	1	5.31E-03	5.31E-03	E	2.65
N	100	0	100.00	1	5.09E-03	5.09E-03	E	2.65
NNE	100	0	100.00	1	2.87E-03	2.87E-03	E	4.70
NE	100	0	100.00	1	2.73E-03	2.73E-03	D	2.65
ENE	100	0	100.00	1	4.56E-03	4.56E-03	F	7.15
E	100	0	100.00	1	5.10E-03	5.10E-03	E	2.65
ESE	100	0	100.00	1	3.05E-03	3.05E-03	E	4.70
SE	100	0	100.00	1	2.80E-03	2.80E-03	D	2.65
SSE	100	0	100.00	1	2.86E-03	2.86E-03	E	4.70
S	12000	0	100.00	1	1.07E-06	1.07E-06	E	7.15
SSW	12000	0	100.00	1	6.32E-07	6.32E-07	D	4.70
SW	12000	0	100.00	1	6.33E-07	6.33E-07	D	4.70
WSW	12000	0	100.00	1	8.34E-07	8.34E-07	D	4.70
W	12000	0	100.00	1	1.45E-06	1.45E-06	E	4.70
WNW	12000	0	100.00	1	2.79E-06	2.79E-06	E	2.65
NW	12000	0	100.00	1	2.86E-06	2.86E-06	E	2.65
NNW	12000	0	100.00	1	2.88E-06	2.88E-06	E	2.65
N	12000	0	100.00	1	2.81E-06	2.81E-06	E	2.65
NNE	12000	0	100.00	1	1.43E-06	1.43E-06	E	4.70
NE	12000	0	100.00	1	1.13E-06	1.13E-06	D	2.65
ENE	12000	0	100.00	1	2.66E-06	2.66E-06	F	7.15
E	12000	0	100.00	1	2.82E-06	2.82E-06	E	2.65
ESE	12000	0	100.00	1	1.79E-06	1.79E-06	E	4.70
SE	12000	0	100.00	1	1.15E-06	1.15E-06	D	2.65
SSE	12000	0	100.00	1	1.33E-06	1.33E-06	D	2.65

Case 2A: X/Q Calculated by Atmospheric Stability Class and Wind Speed

Discussion and Conclusion

This case tests the ability of GXQ to calculate a ground level release, centerline X/Q for each of the atmospheric stability classes (Pasquill A-G) at various wind speeds and distances. The X/Q and diffusion coefficient equations used by GXQ are identical to those used by the GENII program. Verification of correct solution of these equations is achieved by an independent hand calculation. Results agree to within two significant figures. This case acts as a base case for each of the following cases which test various correction factors to the Gaussian straight line plume model. As a second check, diffusion coefficients were obtained from NRC (1982) and used in hand calculations of X/Q. As a result of the difference between the diffusion coefficients used in GENII (Pasquill-Gifford-Turner) and those presented in NRC (1982), there is a difference of from 3 to 21 percent in the X/Qs. The hand calculations and GXQ output file for this case follow.

Table 2A1. Case 2A Check Using GENII 1.485 σ 's.

2*pi =				6.283185	
F(y) =				1	
G(z) =				2	
Atmos. Stability Class	Wind Speed (m/s)	x (m)	Sigmay (m)	Sigmaz (m)	X/Q (1/m ³)
A	12	100	23.41228	14.29972	7.92e-05
B	8	1000	140.8609	110.2337	2.56e-06
C	4	10000	855.7333	497.827	1.87e-07
D	6	100	9.414834	4.55681	1.24e-03
E	4	1000	53.5589	21.33693	6.96e-05
F	1	20000	553.092	58.71554	9.80e-06
G	1	100	3.078542	1.360375	7.60e-02

Table 2A2. Case 2A Hand Calculation Using NRC (1982) σ 's.

Atm. Stab. Class	u (m/s)	x (m)	y (m)	(1) σ_y (m)	(1) σ_z (m)	(2) $f(y)$	(3) $g(z)$	(4) X/Q' (s/m ³)	Δ (%)
A	12.0	100	0	23	15	1	2.0	7.69×10^{-5}	3
B	8.0	1,000	0	160	120	1	2.0	2.07×10^{-6}	19
C	4.0	10,000	0	840	420	1	2.0	2.26×10^{-7}	21
D	6.0	100	0	8.1	4.8	1	2.0	1.36×10^{-3}	10
E	4.0	1,000	0	55	23	1	2.0	6.29×10^{-5}	9
F	1.0	20,000	0	500	58	1	2.0	1.10×10^{-5}	11
G	1.0	100	0	2.7	1.4	1	2.0	8.42×10^{-2}	11

(2) Diffusion coefficients taken NRC (1982).

$$(2) \quad f(y) = \exp\left(-1/2\left(\frac{y}{\sigma_y}\right)^2\right)$$

$$(3) \quad g(z) = 2 \exp\left(-1/2\left(\frac{h_e}{\sigma_z}\right)^2\right)$$

where:

$h_e = 0$ (effective release height)

$$(4) \quad \frac{X}{Q'} = \frac{f(y) g(z)}{2\pi \sigma_y \sigma_z u}$$

WHC-SD-GN-SWD-30003 Rev 1

Current Input File Name: 2a.IN

GXQ Version 4.0
December 19, 1994

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 1.
Code Custodian is Brit E. Hey, WHC, ext. 376-2921.

Run Date = 02/02/95
Run Time = 15:36:47.39

INPUT ECHO:

VV Case 2A: Point Source Ground Level Release

c mode
2

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F F F F

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 0

c PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)	
0.00000E+00	1.00000E+01	1.00000E+03	5.00000E+00	
initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
0.00000E+00	0.00000E+00	0.00000E+00	1.00000E-03	1.00000E-03
ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (w)
2.00000E+01	2.20000E+01	1.00000E+00	1.00000E+00	0.00000E+00
X/Q scaling factor (?)	Wind Speed Exponent			
1.00000E+00	7.80000E-01			

c RECEPTOR DEPENDENT DATA (no line limit)

MODE:

X/Q calculated by stability class and wind speed.

LOGICAL CHOICES:

MODELS SELECTED:

Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

VV Case 2A: Point Source Ground Level Release

ATM. STAB. CLASS	WIND SPEED (m/s)	DISTANCE (m)	OFFSET (m)	RECEPTOR HEIGHT (m)	SCALED X/Q (s/m ³)
A	12.00	100	0	0	7.92E-05
B	8.00	1000	0	0	2.56E-06
C	4.00	10000	0	0	1.87E-07
D	6.00	100	0	0	1.24E-03
E	4.00	1000	0	0	6.90E-05
F	1.00	20000	0	0	9.80E-06
G	1.00	100	0	0	7.60E-02

Case 2B1A: Plume Depletion, Ground Level Constant Elevation Release

Discussion and Conclusion

The 2B1 series of test cases test the source depletion model by comparing GXQ calculated depletion factors to a spreadsheet implementation of the same model. All of the 2B1 test cases use 1 m/s ground level wind speed, Pasquill stability class F, and a deposition velocity of 0.001 m/s. The 2B1 test cases were designed so that the effect of plume elevation could be tested. Depletion factors are calculated for a ground level release, a 100 m stack release, a uniformly rising plume, a uniformly falling plume, a rising plume with a vertical wind speed profile, and a falling plume with a vertical wind speed profile. Each case corresponds to 10,000 seconds of plume travel time. The results of all six cases are summarized in Figure 2B1. Case 2B1A specifically addresses a ground level release out to 10,000m. A comparison of the GXQ calculated depletion factor and that calculated using a spreadsheet show agreement to within an acceptable two significant figures. The difference is due to the different integration technique used in the spreadsheet.

The spreadsheet calculation and the GXQ input file and calculated depletion factor for this case follow. The spreadsheet calculation solves the integral equation 4.1-10 discussed in the GXQ Users' Manual (Hey 1995). Parameter input, vertical diffusion coefficients, and results are provided in the upper box of the table. The lower box is where equation 4.1-10 is solved numerically using the trapezoidal rule applied to 40 distance segments (column 1). The distance segments are geometrically spaced by the multiplier given in the upper answer box. Column 3 is the value of the integrand at the segment boundary whereas column 2 is the value of the integral over the segment. The plume rise/fall (last column) is determined by the average plume height wind speed (column 7, the average of column 8 and the stack level wind speed, urel), distance traveled (column 1), and the gravitational fall velocity (vg from upper input box). The plume height (column 6) used in calculating the vertical offset, g (column 4), is maintained within the bounds of 0.01 m and the mixing height, h.

Figure 2B1. Comparison of GXQ Calculated Plume Depletion Factors

INPUT				ANSWER	
receptor distance, x =	10000.00 m	depletion factor =		0.6529	
wind speed, u =	1.00 m/s	depletion integral value =		1068.79	
stack level wind speed, urel =	1.00 m/s	multiplier used in distance intervals		1.270	
deposition velocity, vd =	0.001 m/s				
gravitational fall velocity, vg =	-0.01 m/s				
mixing height, h =	1000.00 m	SIGMA COEFFICIENTS			
anemometer height, h =	10.00 m	A_1	0.05		
stack height, hs =	0.00 m	B_1	0.81		
vertical wind speed power coeff., p =	0.55	C_1	0.00		
reflection factor, Fref =	2.00	A_2	0.09		
gravitational fall (1=yes, 0=no)? =	0	B_2	0.74		
vertical wind profile (1=yes, 0=no)? =	0	C_2	-0.35		
		A_3	18.05		
		B_3	0.18		
		C_3	-48.60		

distance to receptor x (m)	integral value f dx (s/m)	depletion integrand value g sigma z uhe (unitless)	vertical offset g (unitless)	vertical diffusion coefficient sigma z (m)	bounded plume height hec (m)	average height wind speed ue (m/s)	plume height wind speed uhe (m/s)	effective plume height fhe (m)	rise/fall hgrav (m)
0.70		2.10E+00	0.08	0.04	0.10	1.00	1.00	0.00	0.00
0.89	0.65	4.81E+00	0.23	0.05	0.10	1.00	1.00	0.00	0.00
1.13	1.53	7.94E+00	0.46	0.06	0.10	1.00	1.00	0.00	0.00
1.43	2.81	1.05E+01	0.74	0.07	0.10	1.00	1.00	0.00	0.00
1.82	4.32	1.18E+01	1.02	0.09	0.10	1.00	1.00	0.00	0.00
2.31	5.90	1.21E+01	1.27	0.10	0.10	1.00	1.00	0.00	0.00
2.94	7.39	1.15E+01	1.47	0.13	0.10	1.00	1.00	0.00	0.00
3.73	8.74	1.05E+01	1.62	0.15	0.10	1.00	1.00	0.00	0.00
4.74	9.94	9.23E+00	1.74	0.19	0.10	1.00	1.00	0.00	0.00
6.02	11.01	7.95E+00	1.82	0.23	0.10	1.00	1.00	0.00	0.00
7.65	11.96	6.75E+00	1.87	0.28	0.10	1.00	1.00	0.00	0.00
9.72	12.84	5.67E+00	1.91	0.34	0.10	1.00	1.00	0.00	0.00
12.35	13.67	4.73E+00	1.94	0.41	0.10	1.00	1.00	0.00	0.00
15.68	14.46	3.93E+00	1.96	0.50	0.10	1.00	1.00	0.00	0.00
19.92	15.24	3.26E+00	1.97	0.61	0.10	1.00	1.00	0.00	0.00
25.30	16.03	2.69E+00	1.98	0.74	0.10	1.00	1.00	0.00	0.00
32.14	16.82	2.22E+00	1.99	0.89	0.10	1.00	1.00	0.00	0.00
40.83	17.63	1.83E+00	1.99	1.09	0.10	1.00	1.00	0.00	0.00
51.86	18.46	1.51E+00	1.99	1.32	0.10	1.00	1.00	0.00	0.00
65.87	19.32	1.25E+00	2.00	1.60	0.10	1.00	1.00	0.00	0.00
83.67	20.22	1.03E+00	2.00	1.95	0.10	1.00	1.00	0.00	0.00
106.27	21.14	8.44E-01	2.00	2.37	0.10	1.00	1.00	0.00	0.00
134.99	22.04	6.91E-01	2.00	2.89	0.10	1.00	1.00	0.00	0.00
171.46	22.96	5.68E-01	2.00	3.52	0.10	1.00	1.00	0.00	0.00
217.79	24.00	4.68E-01	2.00	4.27	0.10	1.00	1.00	0.00	0.00
276.64	25.17	3.87E-01	2.00	5.16	0.10	1.00	1.00	0.00	0.00
351.39	26.46	3.21E-01	2.00	6.23	0.10	1.00	1.00	0.00	0.00
446.33	27.88	2.66E-01	2.00	7.51	0.10	1.00	1.00	0.00	0.00
566.93	29.42	2.22E-01	2.00	9.03	0.10	1.00	1.00	0.00	0.00
720.12	31.09	1.84E-01	2.00	10.84	0.10	1.00	1.00	0.00	0.00
914.69	32.90	1.54E-01	2.00	13.01	0.10	1.00	1.00	0.00	0.00
1161.84	34.74	1.27E-01	2.00	15.70	0.10	1.00	1.00	0.00	0.00
1475.77	36.94	1.08E-01	2.00	18.53	0.10	1.00	1.00	0.00	0.00
1874.53	40.09	9.31E-02	2.00	21.48	0.10	1.00	1.00	0.00	0.00
2381.03	44.20	8.14E-02	2.00	24.56	0.10	1.00	1.00	0.00	0.00
3024.39	49.35	7.20E-02	2.00	27.78	0.10	1.00	1.00	0.00	0.00
3841.58	55.65	6.42E-02	2.00	31.14	0.10	1.00	1.00	0.00	0.00
4879.58	63.29	5.77E-02	2.00	34.65	0.10	1.00	1.00	0.00	0.00
6198.05	72.46	5.22E-02	2.00	38.31	0.10	1.00	1.00	0.00	0.00
7872.77	83.46	4.75E-02	2.00	42.14	0.10	1.00	1.00	0.00	0.00
10000.00	96.60	4.34E-02	2.00	46.13	0.10	1.00	1.00	0.00	0.00

VV Case 2B1A: Plume Depletion, Ground Level Constant Elevation Release

C mode

2

C

C LOGICAL CHOICES:

C ifox inorm icdf ichk isite ipop

F F F T F F

C

C X/Q AND WIND SPEED ADJUSTMENT MODELS:

C ipuff idep isrc iwind

0 1 0 0

C DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

C iwake ipm iflow ientr

0 0 0 0

C EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

C (irise igrnd iwash)igrav

0 0 0 0

C

C PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)
--------------------------	--	-------------------------	----------------------------------

0	10	1000	5
---	----	------	---

C

initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
----------------------------------	-----------------------------------	-----------------------------	---------------------------------	--

0	0	0	0.001	0.001
---	---	---	-------	-------

C

ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (w)
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20	22	1	1	0
----	----	---	---	---

C

X/Q scaling factor (?)	Wind Speed Exponent
---------------------------------	---------------------------

1	.78
---	-----

C

C RECEPTOR DEPENDENT DATA (no line limit)

6 1 10000 0 0

----- 2B1A.OUT
plume depletion factor

= 0.654129

Case 2B1B: Plume Depletion, 100m Stack Level Constant Elevation Release

Discussion and Conclusion

Case 2B1B specifically addresses a 100m stack level release out to 10,000m. The plume elevation is constant. A comparison of the GXQ calculated depletion factor and that calculated using a spreadsheet show agreement to within an acceptable two significant figures. The difference is due to the different integration technique used in the spreadsheet.

The GXQ input file, calculated plume depletion factor and spreadsheet follow.

INPUT		ANSWER	
receptor distance, x =	10000.00 m	depletion factor =	0.9945
wind speed, u =	1.00 m/s	depletion integral value =	13.88
stack level wind speed, urel =	1.00 m/s	multiplier used in distance intervals	1.270
deposition velocity, vd =	0.001 m/s	SIGMA COEFFICIENTS	
gravitational fall velocity, vg =	-0.01 m/s		
mixing height, h =	1000.00 m		
anemometer height, h =	10.00 m		
stack height, hs =	100.00 m		
vertical wind speed power coeff., p =	0.55		
reflection factor, Fref =	2.00		
gravitational fall (1=yes, 0=no)? =	0		
vertical wind profile (1=yes, 0=no)? =	0		
		B_1	0.81
		C_1	0.00
		A_2	0.09
		B_2	0.74
		C_2	-0.35
		A_3	18.05
		B_3	0.18
		C_3	-48.60

distance to receptor x (m)	integral value f dx (s/m)	depletion integrand value g sigma z uhe	vertical offset g (unitless)	vertical diffusion coefficient sigma z (m)	bounded plume height h _{ec} (m)	average height wind speed u _e (m/s)	plume height wind speed u _{he} (m/s)	effective plume height fhe (m)	rise/fall hgrav (m)
0.70		0.00E+00	0.00	0.04	100.00	1.00	1.00	100.00	0.00
0.89	0.00	0.00E+00	0.00	0.05	100.00	1.00	1.00	100.00	0.00
1.13	0.00	0.00E+00	0.00	0.06	100.00	1.00	1.00	100.00	0.00
1.43	0.00	0.00E+00	0.00	0.07	100.00	1.00	1.00	100.00	0.00
1.82	0.00	0.00E+00	0.00	0.09	100.00	1.00	1.00	100.00	0.00
2.31	0.00	0.00E+00	0.00	0.10	100.00	1.00	1.00	100.00	0.00
2.94	0.00	0.00E+00	0.00	0.13	100.00	1.00	1.00	100.00	0.00
3.73	0.00	0.00E+00	0.00	0.15	100.00	1.00	1.00	100.00	0.00
4.74	0.00	0.00E+00	0.00	0.19	100.00	1.00	1.00	100.00	0.00
6.02	0.00	0.00E+00	0.00	0.23	100.00	1.00	1.00	100.00	0.00
7.65	0.00	0.00E+00	0.00	0.28	100.00	1.00	1.00	100.00	0.00
9.72	0.00	0.00E+00	0.00	0.34	100.00	1.00	1.00	100.00	0.00
12.35	0.00	0.00E+00	0.00	0.41	100.00	1.00	1.00	100.00	0.00
15.68	0.00	0.00E+00	0.00	0.50	100.00	1.00	1.00	100.00	0.00
19.92	0.00	0.00E+00	0.00	0.61	100.00	1.00	1.00	100.00	0.00
25.30	0.00	0.00E+00	0.00	0.74	100.00	1.00	1.00	100.00	0.00
32.14	0.00	0.00E+00	0.00	0.89	100.00	1.00	1.00	100.00	0.00
40.83	0.00	0.00E+00	0.00	1.09	100.00	1.00	1.00	100.00	0.00
51.86	0.00	0.00E+00	0.00	1.32	100.00	1.00	1.00	100.00	0.00
65.87	0.00	0.00E+00	0.00	1.60	100.00	1.00	1.00	100.00	0.00
83.67	0.00	0.00E+00	0.00	1.95	100.00	1.00	1.00	100.00	0.00
106.27	0.00	0.00E+00	0.00	2.37	100.00	1.00	1.00	100.00	0.00
134.99	0.00	2.22E-260	0.00	2.89	100.00	1.00	1.00	100.00	0.00
171.46	0.00	3.65E-176	0.00	3.52	100.00	1.00	1.00	100.00	0.00
217.79	0.00	3.78E-120	0.00	4.27	100.00	1.00	1.00	100.00	0.00
276.64	0.00	1.50E-82	0.00	5.16	100.00	1.00	1.00	100.00	0.00
351.39	0.00	3.99E-57	0.00	6.23	100.00	1.00	1.00	100.00	0.00
446.33	0.00	7.79E-40	0.00	7.51	100.00	1.00	1.00	100.00	0.00
566.93	0.00	5.05E-28	0.00	9.03	100.00	1.00	1.00	100.00	0.00
720.12	0.00	6.29E-20	0.00	10.84	100.00	1.00	1.00	100.00	0.00
914.69	0.00	2.29E-14	0.00	13.01	100.00	1.00	1.00	100.00	0.00
1161.84	0.00	1.97E-10	0.00	15.70	100.00	1.00	1.00	100.00	0.00
1475.77	0.00	5.10E-08	0.00	18.53	100.00	1.00	1.00	100.00	0.00
1874.53	0.00	1.83E-06	0.00	21.48	100.00	1.00	1.00	100.00	0.00
2381.03	0.01	2.05E-05	0.00	24.56	100.00	1.00	1.00	100.00	0.00
3024.39	0.04	1.11E-04	0.00	27.78	100.00	1.00	1.00	100.00	0.00
3841.58	0.20	3.70E-04	0.01	31.14	100.00	1.00	1.00	100.00	0.00
4879.58	0.66	8.97E-04	0.03	34.65	100.00	1.00	1.00	100.00	0.00
6198.05	1.73	1.73E-03	0.07	38.31	100.00	1.00	1.00	100.00	0.00
7872.77	3.83	2.84E-03	0.12	42.14	100.00	1.00	1.00	100.00	0.00
10000.00	7.42	4.14E-03	0.19	46.13	100.00	1.00	1.00	100.00	0.00

VV Case 2B1B: Plume Depletion, 100m Stack Level Constant Elevation Release

c mode
2

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F T F F

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 1 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 0

c

c PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)	
100	10	1000	5	
initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
0	0	0	0.001	0.001
ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (w)
20	22	1	1	0
X/Q scaling factor (?)	Wind Speed Exponent			
1	.78			

c

c RECEPTOR DEPENDENT DATA (no line limit)

6 1 10000 0 0

----- 2B1B.OUT
plume depletion factor = 0.994481

Case 2B1C: Plume Depletion, Ground Level Rising Plume Release

Discussion and Conclusion

Case 2B1C specifically addresses a ground level rising plume release out to 10,000m. A negative gravitational velocity is used to provide a uniform plume rise. A comparison of the GXQ calculated depletion factor and that calculated using a spreadsheet show agreement to within an acceptable two significant figures. The difference is due to the different integration technique used in the spreadsheet.

The GXQ input file, calculated plume depletion factor and spreadsheet follow.

INPUT				ANSWER	
receptor distance, x =	10000.00 m	depletion factor =		0.7571	
wind speed, u =	1.00 m/s	depletion integral value =		697.41	
stack level wind speed, urel =	1.00 m/s	multiplier used in distance intervals		1.270	
deposition velocity, vd =	0.001 m/s	SIGMA COEFFICIENTS			
gravitational fall velocity, vg =	-0.01 m/s	A_1	0.05		
mixing height, h =	1000.00 m	B_1	0.81		
anemometer height, h =	10.00 m	C_1	0.00		
stack height, hs =	0.00 m	A_2	0.09		
vertical wind speed power coeff., p =	0.55	B_2	0.74		
reflection factor, Fref =	2.00	C_2	-0.35		
gravitational fall (1=yes, 0=no)? =	1	A_3	18.05		
vertical wind profile (1=yes, 0=no)? =	0	B_3	0.18		
		C_3	-48.60		

distance to receptor x (m)	integral value f dx (s/m)	depletion integrand value g sigma z uhe (unitless)	vertical offset g	vertical diffusion coefficient sigma z (m)	bounded plume height hec (m)	average height wind speed ue (m/s)	plume height wind speed uhe (m/s)	effective plume height fhe (m)	ise/fall hgrav (m)
0.70		2.10E+00	0.08	0.04	0.10	1.00	1.00	0.01	-0.01
0.89	0.65	4.81E+00	0.23	0.05	0.10	1.00	1.00	0.01	-0.01
1.13	1.53	7.94E+00	0.46	0.06	0.10	1.00	1.00	0.01	-0.01
1.43	2.81	1.05E+01	0.74	0.07	0.10	1.00	1.00	0.01	-0.01
1.82	4.32	1.18E+01	1.02	0.09	0.10	1.00	1.00	0.02	-0.02
2.31	5.90	1.21E+01	1.27	0.10	0.10	1.00	1.00	0.02	-0.02
2.94	7.39	1.15E+01	1.47	0.13	0.10	1.00	1.00	0.03	-0.03
3.73	8.74	1.05E+01	1.62	0.15	0.10	1.00	1.00	0.04	-0.04
4.74	9.94	9.23E+00	1.74	0.19	0.10	1.00	1.00	0.05	-0.05
6.02	11.01	7.95E+00	1.82	0.23	0.10	1.00	1.00	0.06	-0.06
7.65	11.96	6.75E+00	1.87	0.28	0.10	1.00	1.00	0.08	-0.08
9.72	12.84	5.67E+00	1.91	0.34	0.10	1.00	1.00	0.10	-0.10
12.35	13.57	4.66E+00	1.91	0.41	0.12	1.00	1.00	0.12	-0.12
15.68	14.15	3.82E+00	1.90	0.50	0.16	1.00	1.00	0.16	-0.16
19.92	14.73	3.13E+00	1.89	0.61	0.20	1.00	1.00	0.20	-0.20
25.30	15.32	2.56E+00	1.89	0.74	0.25	1.00	1.00	0.25	-0.25
32.14	15.94	2.10E+00	1.87	0.89	0.32	1.00	1.00	0.32	-0.32
40.83	16.57	1.72E+00	1.86	1.09	0.41	1.00	1.00	0.41	-0.41
51.86	17.21	1.40E+00	1.85	1.32	0.52	1.00	1.00	0.52	-0.52
65.87	17.87	1.15E+00	1.84	1.60	0.66	1.00	1.00	0.66	-0.66
83.67	18.55	9.37E-01	1.82	1.95	0.84	1.00	1.00	0.84	-0.84
106.27	19.23	7.64E-01	1.81	2.37	1.06	1.00	1.00	1.06	-1.06
134.99	19.87	6.20E-01	1.79	2.89	1.35	1.00	1.00	1.35	-1.35
171.46	20.51	5.05E-01	1.78	3.52	1.71	1.00	1.00	1.71	-1.71
217.79	21.21	4.11E-01	1.76	4.27	2.18	1.00	1.00	2.18	-2.18
276.64	21.97	3.35E-01	1.73	5.16	2.77	1.00	1.00	2.77	-2.77
351.39	22.77	2.74E-01	1.71	6.23	3.51	1.00	1.00	3.51	-3.51
446.33	23.59	2.23E-01	1.68	7.51	4.46	1.00	1.00	4.46	-4.46
566.93	24.43	1.82E-01	1.64	9.03	5.67	1.00	1.00	5.67	-5.67
720.12	25.26	1.48E-01	1.60	10.84	7.20	1.00	1.00	7.20	-7.20
914.69	26.07	1.20E-01	1.56	13.01	9.15	1.00	1.00	9.15	-9.15
1161.84	26.81	9.69E-02	1.52	15.70	11.62	1.00	1.00	11.62	-11.62
1475.77	27.54	7.86E-02	1.46	18.53	14.76	1.00	1.00	14.76	-14.76
1874.53	28.36	6.36E-02	1.37	21.48	18.75	1.00	1.00	18.75	-18.75
2381.03	29.00	5.09E-02	1.25	24.56	23.81	1.00	1.00	23.81	-23.81
3024.39	29.18	3.98E-02	1.11	27.78	30.24	1.00	1.00	30.24	-30.24
3841.58	28.53	3.00E-02	0.93	31.14	38.42	1.00	1.00	38.42	-38.42
4879.58	26.69	2.14E-02	0.74	34.65	48.80	1.00	1.00	48.80	-48.80
6198.05	23.42	1.41E-02	0.54	38.31	61.98	1.00	1.00	61.98	-61.98
7872.77	18.75	8.29E-03	0.35	42.14	78.73	1.00	1.00	78.73	-78.73
10000.00	13.21	4.14E-03	0.19	46.13	100.00	1.00	1.00	100.00	-100.00

VV Case 2B1C: Plume Depletion, Ground Level Rising Plume

c mode
2

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F T F F

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 1 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 1

c

c PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)	
0	10	1000	5	
initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
0	0	0	0.001	-.01
ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (w)
20	22	1	1	0
X/Q scaling factor (?)	Wind Speed Exponent			
1	.78			

c

c RECEPTOR DEPENDENT DATA (no line limit)

6 1 10000 0 0

----- 2B1C.OUT
plume depletion factor = 0.758690

Case 2B1D: Plume Depletion, 100m Stack Level Falling Plume Release

Discussion and Conclusion

Case 2B1D specifically addresses a 100m stack level falling plume release out to 10,000m. The plume is falling uniformly at a constant velocity due to gravitational settling. A comparison of the GXQ calculated depletion factor and that calculated using a spreadsheet show agreement to within an acceptable two significant figures. The difference is due to the different integration technique used in the spreadsheet.

The GXQ input file, calculated plume depletion factor and spreadsheet follow.

INPUT		ANSWER	
receptor distance, x =	10000.00 m	depletion factor =	0.9200
wind speed, u =	1.00 m/s	depletion integral value =	208.87
stack level wind speed, urel =	1.00 m/s	multiplier used in distance intervals	1.031
deposition velocity, vd =	0.001 m/s		
gravitational fall velocity, vg =	0.01 m/s		
mixing height, h =	1000.00 m	SIGMA COEFFICIENTS	
anemometer height, h =	10.00 m	A_1	0.05
stack height, hs =	100.00 m	B_1	0.81
vertical wind speed power coeff., p =	0.55	C_1	0.00
reflection factor, Fref =	2.00	A_2	0.09
gravitational fall (1=yes, 0=no)? =	1	B_2	0.74
vertical wind profile (1=yes, 0=no)? =	0	C_2	-0.35
		A_3	18.05
		B_3	0.18
		C_3	-48.60

distance to receptor x (m)	integral value f dx (s/m)	depletion integrand value g sigma z uhe (unitless)	vertical offset g (unitless)	vertical diffusion oefficien sigma z (m)	bounded plume height hec (m)	average height wind speed ue (m/s)	plume height wind speed uhe (m/s)	effective plume height fhe (m)	ise/fall hgrav (m)
3000.00		2.95E-03	0.08	27.67	70.00	1.00	1.00	70.00	30.00
3091.67	0.29	3.46E-03	0.10	28.09	69.08	1.00	1.00	69.08	30.92
3186.14	0.35	4.03E-03	0.11	28.50	68.14	1.00	1.00	68.14	31.86
3283.50	0.42	4.66E-03	0.13	28.92	67.16	1.00	1.00	67.16	32.84
3383.83	0.50	5.36E-03	0.16	29.34	66.16	1.00	1.00	66.16	33.84
3487.23	0.59	6.13E-03	0.18	29.77	65.13	1.00	1.00	65.13	34.87
3593.79	0.70	6.97E-03	0.21	30.19	64.06	1.00	1.00	64.06	35.94
3703.61	0.82	7.89E-03	0.24	30.62	62.96	1.00	1.00	62.96	37.04
3816.78	0.95	8.87E-03	0.28	31.05	61.83	1.00	1.00	61.83	38.17
3933.41	1.10	9.92E-03	0.31	31.48	60.67	1.00	1.00	60.67	39.33
4053.60	1.26	1.10E-02	0.35	31.92	59.46	1.00	1.00	59.46	40.54
4177.47	1.44	1.22E-02	0.40	32.35	58.23	1.00	1.00	58.23	41.77
4305.12	1.64	1.35E-02	0.44	32.79	56.95	1.00	1.00	56.95	43.05
4436.67	1.86	1.48E-02	0.49	33.24	55.63	1.00	1.00	55.63	44.37
4572.24	2.10	1.62E-02	0.55	33.68	54.28	1.00	1.00	54.28	45.72
4711.95	2.36	1.76E-02	0.60	34.13	52.88	1.00	1.00	52.88	47.12
4855.93	2.65	1.91E-02	0.66	34.58	51.44	1.00	1.00	51.44	48.56
5004.32	2.95	2.07E-02	0.72	35.03	49.96	1.00	1.00	49.96	50.04
5157.23	3.28	2.22E-02	0.79	35.48	48.43	1.00	1.00	48.43	51.57
5314.82	3.62	2.38E-02	0.86	35.94	46.85	1.00	1.00	46.85	53.15
5477.23	3.99	2.54E-02	0.92	36.40	45.23	1.00	1.00	45.23	54.77
5644.59	4.38	2.70E-02	1.00	36.86	43.55	1.00	1.00	43.55	56.45
5817.07	4.79	2.86E-02	1.07	37.33	41.83	1.00	1.00	41.83	58.17
5994.83	5.22	3.02E-02	1.14	37.79	40.05	1.00	1.00	40.05	59.95
6178.01	5.67	3.17E-02	1.21	38.26	38.22	1.00	1.00	38.22	61.78
6366.79	6.14	3.33E-02	1.29	38.73	36.33	1.00	1.00	36.33	63.67
6561.34	6.61	3.47E-02	1.36	39.21	34.39	1.00	1.00	34.39	65.61
6761.83	7.10	3.61E-02	1.43	39.69	32.38	1.00	1.00	32.38	67.62
6968.45	7.60	3.75E-02	1.50	40.16	30.32	1.00	1.00	30.32	69.68
7181.39	8.11	3.87E-02	1.57	40.65	28.19	1.00	1.00	28.19	71.81
7400.83	8.61	3.98E-02	1.64	41.13	25.99	1.00	1.00	25.99	74.01
7626.97	9.12	4.08E-02	1.70	41.62	23.73	1.00	1.00	23.73	76.27
7860.03	9.62	4.17E-02	1.76	42.11	21.40	1.00	1.00	21.40	78.60
8100.21	10.12	4.25E-02	1.81	42.60	19.00	1.00	1.00	19.00	81.00
8347.73	10.60	4.31E-02	1.86	43.10	16.52	1.00	1.00	16.52	83.48
8602.81	11.06	4.36E-02	1.90	43.60	13.97	1.00	1.00	13.97	86.03
8865.68	11.50	4.39E-02	1.93	44.10	11.34	1.00	1.00	11.34	88.66
9136.59	11.90	4.40E-02	1.96	44.60	8.63	1.00	1.00	8.63	91.37
9415.77	12.28	4.40E-02	1.98	45.11	5.84	1.00	1.00	5.84	94.16
9703.49	12.62	4.38E-02	2.00	45.62	2.97	1.00	1.00	2.97	97.03
10000.00	12.91	4.34E-02	2.00	46.13	0.10	1.00	1.00	0.00	100.00

VV Case 2B1D: Plume Depletion, 100m Stack Level Falling Plume

C mode

2

C

C LOGICAL CHOICES:

C ifox inorm icdf ichk isite ipop

F F F T F F

C

C X/Q AND WIND SPEED ADJUSTMENT MODELS:

C ipuff idep isrc iwind

0 1 0 0

C DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

C iwake ipm iflow ientr

0 0 0 0

C EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

C (irise igrnd iwash)igrav

0 0 0 1

C

C PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)
100	10	1000	5

C

initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
0	0	0	0.001	0.01

C

ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(l) (w)
20	22	1	1	0

C

X/Q scaling factor (?)	Wind Speed Exponent
1	.78

C

C RECEPTOR DEPENDENT DATA (no line limit)

6 1 10000 0 0

----- 2B1D.OUT
plume depletion factor

= 0.919601

Case 2B1E: Plume Depletion, Ground Level Rising Plume with Vertical Wind Speed Profile

Discussion and Conclusion

Case 2B1E specifically addresses a ground level release out to 22,000m. The travel time is approximately 10,000s. The plume is released at ground level but rises uniformly and at constant velocity. A negative gravitational settling velocity is used to cause the plume to rise. Additionally, the wind speed increases with plume centerline elevation according to the power law relationship. A comparison of the GXQ calculated depletion factor and that calculated using a spreadsheet show agreement to within an acceptable two significant figures. The difference is due to the different integration technique used in the spreadsheet.

The GXQ input file, calculated plume depletion factor and spreadsheet follow.

INPUT				ANSWER	
receptor distance, x =	22000.00 m	depletion factor =		0.7458	
wind speed, u =	1.00 m/s	depletion integral value =		735.32	
stack level wind speed, urel =	1.00 m/s	multiplier used in distance intervals		1.295	
deposition velocity, vd =	0.001 m/s	SIGMA COEFFICIENTS			
gravitational fall velocity, vg =	-0.01 m/s	A_1	0.05		
mixing height, h =	1000.00 m	B_1	0.81		
anemometer height, h =	10.00 m	C_1	0.00		
stack height, hs =	0.00 m	A_2	0.09		
vertical wind speed power coeff., p =	0.55	B_2	0.74		
reflection factor, Fref =	2.00	C_2	-0.35		
gravitational fall (1=yes, 0=no)? =	1	A_3	18.05		
vertical wind profile (1=yes, 0=no)? =	1	B_3	0.18		
		C_3	-48.60		

distance to receptor x (m)	integral value f dx (s/m)	depletion integrand value g sigma z uhe (unitless)	vertical offset g (m)	vertical diffusion coefficient sigma z (m)	bounded plume height hec (m)	average height wind speed ue (m/s)	plume height wind speed uhe (m/s)	effective plume height fhe (m)	ise/fall hgrav (m)
0.70		2.10E+00	0.08	0.04	0.10	1.00	1.00	0.01	-0.01
0.91	0.74	5.07E+00	0.25	0.05	0.10	1.00	1.00	0.01	-0.01
1.17	1.81	8.42E+00	0.51	0.06	0.10	1.00	1.00	0.01	-0.01
1.52	3.36	1.09E+01	0.81	0.07	0.10	1.00	1.00	0.02	-0.02
1.97	5.16	1.20E+01	1.11	0.09	0.10	1.00	1.00	0.02	-0.02
2.55	6.99	1.19E+01	1.36	0.11	0.10	1.00	1.00	0.03	-0.03
3.31	8.68	1.11E+01	1.55	0.14	0.10	1.00	1.00	0.03	-0.03
4.29	10.18	9.77E+00	1.69	0.17	0.10	1.00	1.00	0.04	-0.04
5.55	11.50	8.38E+00	1.79	0.21	0.10	1.00	1.00	0.06	-0.06
7.19	12.66	7.05E+00	1.86	0.26	0.10	1.00	1.00	0.07	-0.07
9.32	13.71	5.85E+00	1.91	0.33	0.10	1.00	1.00	0.09	-0.09
12.07	14.60	4.75E+00	1.91	0.40	0.12	1.00	1.00	0.12	-0.12
15.64	15.30	3.83E+00	1.90	0.50	0.16	1.00	1.00	0.16	-0.16
20.26	15.98	3.09E+00	1.89	0.61	0.20	1.00	1.00	0.20	-0.20
26.25	16.68	2.49E+00	1.88	0.76	0.26	1.00	1.00	0.26	-0.26
34.01	17.40	2.00E+00	1.87	0.94	0.34	1.00	1.00	0.34	-0.34
44.06	18.15	1.61E+00	1.86	1.15	0.44	1.00	1.00	0.44	-0.44
57.08	18.91	1.29E+00	1.85	1.43	0.57	1.00	1.00	0.57	-0.57
73.94	19.69	1.04E+00	1.83	1.76	0.74	1.00	1.00	0.74	-0.74
95.79	20.49	8.35E-01	1.81	2.17	0.96	1.00	1.00	0.96	-0.96
124.10	21.26	6.67E-01	1.80	2.70	1.24	1.00	1.00	1.24	-1.24
160.77	22.01	5.33E-01	1.78	3.34	1.61	1.00	1.00	1.61	-1.61
208.27	22.81	4.27E-01	1.76	4.12	2.08	1.00	1.00	2.08	-2.08
269.81	23.69	3.43E-01	1.74	5.06	2.70	1.00	1.00	2.70	-2.70
349.54	24.62	2.75E-01	1.71	6.21	3.50	1.00	1.00	3.50	-3.50
452.82	25.59	2.21E-01	1.67	7.59	4.53	1.00	1.00	4.53	-4.53
586.62	26.57	1.77E-01	1.64	9.27	5.87	1.00	1.00	5.87	-5.87
759.96	27.54	1.41E-01	1.60	11.30	7.60	1.00	1.00	7.60	-7.60
984.52	28.49	1.13E-01	1.55	13.76	9.85	1.00	1.00	9.85	-9.85
1275.44	28.41	8.28E-02	1.54	16.79	12.09	1.06	1.11	12.09	-12.09
1652.31	27.21	6.16E-02	1.52	19.91	14.76	1.12	1.24	14.76	-14.76
2140.55	26.33	4.63E-02	1.48	23.17	17.98	1.19	1.38	17.98	-17.98
2773.05	25.66	3.49E-02	1.43	26.60	21.86	1.27	1.54	21.86	-21.86
3592.45	25.09	2.63E-02	1.36	30.19	26.52	1.35	1.71	26.52	-26.52
4653.97	24.51	1.98E-02	1.28	33.94	32.10	1.45	1.90	32.10	-32.10
6029.16	23.83	1.48E-02	1.18	37.88	38.80	1.55	2.11	38.80	-38.80
7810.70	22.96	1.09E-02	1.07	42.01	46.81	1.67	2.34	46.81	-46.81
10118.67	21.81	7.95E-03	0.95	46.33	56.39	1.79	2.59	56.39	-56.39
13108.60	20.32	5.64E-03	0.82	50.86	67.82	1.93	2.87	67.82	-67.82
16982.03	18.44	3.88E-03	0.68	55.60	81.46	2.08	3.17	81.46	-81.46
22000.00	16.17	2.57E-03	0.54	60.57	97.71	2.25	3.50	97.71	-97.71

VV Case 2B1E: Plume Depletion, Ground Level Rising Plume w/ Wind Profile

c mode
2

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F T F F

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 1 0 1

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 1

c PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)
0	10	1000	5

initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
0	0	0	0.001	-0.01

ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (w)
20	22	1	1	0

X/Q scaling factor (?)	Wind Speed Exponent
1	.78

c RECEPTOR DEPENDENT DATA (no line limit)

6 1 22000 0 0

----- 2B1E.OUT
plume depletion factor = 0.748890

Case 2B1F: Plume Depletion, 100m Stack Level Constant Elevation Release

Discussion and Conclusion

Case 2B1F specifically addresses a 100m stack level release out to 22,000m. The plume travel time is approximately 10,000s. The plume is released at 100m and falls uniformly and at constant velocity due to gravitational settling. Additionally, the wind speed increases with plume centerline elevation according to the power law relationship. A comparison of the GXQ calculated depletion factor and that calculated using a spreadsheet show agreement to within two significant figures. The difference is due to the different integration technique used in the spreadsheet.

The GXQ input file, calculated plume depletion factor and spreadsheet follow.

INPUT		ANSWER	
receptor distance, x =	22000.00 m	depletion factor =	0.9296
wind speed, u =	1.00 m/s	depletion integral value =	182.91
stack level wind speed, u _{rel} =	3.55 m/s	multiplier used in distance intervals	1.044
deposition velocity, v _d =	0.001 m/s	SIGMA COEFFICIENTS	
gravitational fall velocity, v _g =	0.01 m/s		
mixing height, h =	1000.00 m	A_1	0.05
anemometer height, h _a =	10.00 m	B_1	0.81
stack height, h _s =	100.00 m	C_1	0.00
vertical wind speed power coeff., p =	0.55	A_2	0.09
reflection factor, F _{ref} =	2.00	B_2	0.74
gravitational fall (1=yes, 0=no)? =	1	C_2	-0.35
vertical wind profile (1=yes, 0=no)? =	1	A_3	18.05
		B_3	0.18
		C_3	-48.60

distance to receptor x (m)	integral value f dx (s/m)	depletion integrand value g sigma z u _{he} (unitless)	vertical offset g (unitless)	vertical diffusion coefficient sigma z (m)	bounded plume height h _{ec} (m)	average height wind speed u _e (m/s)	plume height wind speed u _{he} (m/s)	effective plume height f _{he} (m)	rise/fall h _{grav} (m)
4000.00		3.94E-04	0.04	31.72	88.34	3.43	3.31	88.34	11.66
4174.16	0.08	4.69E-04	0.05	32.34	87.82	3.43	3.30	87.82	12.18
4355.90	0.09	5.55E-04	0.06	32.97	87.26	3.42	3.29	87.26	12.74
4545.56	0.11	6.50E-04	0.07	33.59	86.69	3.41	3.28	86.69	13.31
4743.47	0.14	7.57E-04	0.08	34.23	86.08	3.41	3.27	86.08	13.92
4950.00	0.17	8.75E-04	0.10	34.87	85.45	3.40	3.25	85.45	14.55
5165.52	0.20	1.01E-03	0.12	35.51	84.78	3.39	3.24	84.78	15.22
5390.43	0.24	1.15E-03	0.13	36.16	84.08	3.39	3.23	84.08	15.92
5625.13	0.29	1.30E-03	0.15	36.81	83.35	3.38	3.21	83.35	16.65
5870.05	0.34	1.47E-03	0.18	37.47	82.59	3.37	3.19	82.59	17.41
6125.63	0.40	1.66E-03	0.20	38.13	81.78	3.36	3.18	81.78	18.22
6392.34	0.47	1.85E-03	0.23	38.80	80.94	3.35	3.16	80.94	19.06
6670.66	0.54	2.06E-03	0.26	39.47	80.05	3.34	3.14	80.05	19.95
6961.10	0.63	2.29E-03	0.29	40.15	79.12	3.33	3.12	79.12	20.88
7264.19	0.73	2.53E-03	0.32	40.83	78.14	3.32	3.10	78.14	21.86
7580.47	0.84	2.79E-03	0.36	41.52	77.11	3.31	3.08	77.11	22.89
7910.52	0.97	3.07E-03	0.40	42.21	76.03	3.30	3.05	76.03	23.97
8254.94	1.11	3.36E-03	0.44	42.91	74.89	3.29	3.03	74.89	25.11
8614.36	1.26	3.67E-03	0.48	43.62	73.69	3.27	3.00	73.69	26.31
8989.43	1.44	4.00E-03	0.53	44.33	72.42	3.26	2.97	72.42	27.58
9380.83	1.63	4.35E-03	0.58	45.04	71.09	3.24	2.94	71.09	28.91
9789.27	1.85	4.71E-03	0.63	45.77	69.68	3.23	2.91	69.68	30.32
10215.50	2.09	5.11E-03	0.68	46.49	68.19	3.21	2.87	68.19	31.81
10660.28	2.36	5.52E-03	0.74	47.22	66.61	3.19	2.84	66.61	33.39
11124.43	2.66	5.96E-03	0.80	47.96	64.94	3.17	2.80	64.94	35.06
11608.78	3.00	6.43E-03	0.86	48.71	63.17	3.15	2.76	63.17	36.83
12114.23	3.37	6.92E-03	0.93	49.46	61.29	3.13	2.71	61.29	38.71
12641.68	3.79	7.45E-03	1.00	50.21	59.28	3.10	2.66	59.28	40.72
13192.10	4.26	8.03E-03	1.07	50.97	57.14	3.08	2.61	57.14	42.86
13766.48	4.79	8.64E-03	1.14	51.74	54.85	3.05	2.55	54.85	45.15
14365.87	5.38	9.31E-03	1.22	52.51	52.39	3.02	2.49	52.39	47.61
14991.36	6.06	1.00E-02	1.29	53.29	49.73	2.98	2.42	49.73	50.27
15644.08	6.83	1.09E-02	1.37	54.07	46.85	2.94	2.34	46.85	53.15
16325.23	7.72	1.18E-02	1.46	54.86	43.69	2.90	2.25	43.69	56.31
17036.03	8.77	1.29E-02	1.54	55.66	40.20	2.85	2.15	40.20	59.80
17777.77	10.04	1.42E-02	1.63	56.46	36.27	2.79	2.03	36.27	63.73
18551.82	11.63	1.59E-02	1.72	57.27	31.74	2.72	1.89	31.74	68.26
19359.56	13.80	1.83E-02	1.81	58.09	26.20	2.62	1.70	26.20	73.80
20202.47	17.55	2.33E-02	1.91	58.91	18.13	2.47	1.39	18.13	81.87
21082.09	24.88	3.32E-02	1.99	59.74	7.29	2.27	1.00	7.29	92.71
22000.00	30.38	3.30E-02	2.00	60.57	3.26	2.27	1.00	3.26	96.74

VV Case 2B1F: Plume Depletion, 100m Stack Level Falling Plume w/ Wind Profile

C mode

2

C

C LOGICAL CHOICES:

C ifox inorm icdf ichk isite ipop

F F F T F F

C

C X/Q AND WIND SPEED ADJUSTMENT MODELS:

C ipuff idep isrc iwind

0 1 0 1

C DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

C iwake ipm iflow ientr

0 0 0 0

C EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

C (irise igrnd iwash)igrav

0 0 0 1

C

C PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)
--------------------------	--	-------------------------	----------------------------------

100	10	1000	5
-----	----	------	---

C

initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
----------------------------------	-----------------------------------	-----------------------------	---------------------------------	--

0	0	0	0.001	0.01
---	---	---	-------	------

C

ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(l) (w)
-------------------------------	--	---	----------------------------	--

20	22	1	1	0
----	----	---	---	---

C

X/Q scaling factor (?)	Wind Speed Exponent
---------------------------------	---------------------------

1	.78
---	-----

C

C RECEPTOR DEPENDENT DATA (no line limit)

6 1 22000 0 0

----- 2B1F.OUT

plume depletion factor = 0.924978

Case 2B2 and 2B3: Comparison of Plume Depletion Model to Published Results

Discussion and Conclusion

These cases provide additional testing of the plume depletion model implemented in GXQ. As an additional verification, the plume depletion curves of Slade (1968) are reproduced at selected distances, release heights and stability classes A through F. A graphical comparison of the calculated points to the published curves shows excellent agreement. Therefore, the model implemented in GXQ appears to be correct and consistent with Slade (1968).

The GXQ input files, and GXQ calculated plume depletion factors, and GXQ results superimposed on the published plume depletion curves (Slade 1968) follow.

VV Case 2B2: Plume Depletion Comparisons to Slade

c mode
2

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F T F F

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 1 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 0

c

c PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)	
0	10	1000	5	
initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
0	0	0	0.01	0.001
ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (w)
20	22	1	1	0
X/Q scaling factor (?)	Wind Speed Exponent			
1	.78			

c

c RECEPTOR DEPENDENT DATA (no line limit)

1	1.0	100	0	0
2	1.0	100	0	0
3	1.0	100	0	0
4	1.0	100	0	0
5	1.0	100	0	0
6	1.0	100	0	0
1	1.0	1000	0	0

2	1.0	1000	0	0
3	1.0	1000	0	0
4	1.0	1000	0	0
5	1.0	1000	0	0
6	1.0	1000	0	0
1	1.0	10000	0	0
2	1.0	10000	0	0
3	1.0	10000	0	0
4	1.0	10000	0	0
5	1.0	10000	0	0
6	1.0	10000	0	0
1	1.0	100000	0	0
2	1.0	100000	0	0
3	1.0	100000	0	0
4	1.0	100000	0	0
5	1.0	100000	0	0
6	1.0	100000	0	0

----- 2B2.OUT	
plume depletion factor	= 0.776647
plume depletion factor	= 0.733604
plume depletion factor	= 0.662796
plume depletion factor	= 0.551264
plume depletion factor	= 0.481311
plume depletion factor	= 0.378169
plume depletion factor	= 0.704133
plume depletion factor	= 0.614074
plume depletion factor	= 0.504993
plume depletion factor	= 0.345017
plume depletion factor	= 0.250542
plume depletion factor	= 0.134892
plume depletion factor	= 0.668036
plume depletion factor	= 0.522464
plume depletion factor	= 0.361665
plume depletion factor	= 0.140272
plume depletion factor	= 0.615702E-01
plume depletion factor	= 0.143428E-01
plume depletion factor	= 0.659435
plume depletion factor	= 0.258887
plume depletion factor	= 0.144009
plume depletion factor	= 0.123927E-01
plume depletion factor	= 0.378526E-03
plume depletion factor	= 0.100216E-05

VV Case 2B3: Plume Depletion Comparisons to Slade

c mode
2

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F T F F

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 1 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 0

c

c PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)	
50	10	1000	5	
initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
0	0	0	0.01	0.001
ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (w)
20	22	1	1	0
X/Q scaling factor (?)	Wind Speed Exponent			
1	.78			

c

c RECEPTOR DEPENDENT DATA (no line limit)

1	1.0	100	0	0
2	1.0	100	0	0
3	1.0	100	0	0
4	1.0	100	0	0
5	1.0	100	0	0
6	1.0	100	0	0
1	1.0	1000	0	0

2	1.0	1000	0	0
3	1.0	1000	0	0
4	1.0	1000	0	0
5	1.0	1000	0	0
6	1.0	1000	0	0
1	1.0	10000	0	0
2	1.0	10000	0	0
3	1.0	10000	0	0
4	1.0	10000	0	0
5	1.0	10000	0	0
6	1.0	10000	0	0
1	1.0	100000	0	0
2	1.0	100000	0	0
3	1.0	100000	0	0
4	1.0	100000	0	0
5	1.0	100000	0	0
6	1.0	100000	0	0

----- 2B3.OUT

plume depletion factor	=	0.999991
plume depletion factor	=	1.000000
plume depletion factor	=	1.000000
plume depletion factor	=	1.000000
plume depletion factor	=	1.000000
plume depletion factor	=	1.000000
plume depletion factor	=	0.957660
plume depletion factor	=	0.938514
plume depletion factor	=	0.944568
plume depletion factor	=	0.977887
plume depletion factor	=	0.995312
plume depletion factor	=	0.999920
plume depletion factor	=	0.908690
plume depletion factor	=	0.801099
plume depletion factor	=	0.692170
plume depletion factor	=	0.497547
plume depletion factor	=	0.453236
plume depletion factor	=	0.517638
plume depletion factor	=	0.896990
plume depletion factor	=	0.396956
plume depletion factor	=	0.275687
plume depletion factor	=	0.461916E-01
plume depletion factor	=	0.402390E-02
plume depletion factor	=	0.285905E-03

Figure 2B23. Graphical Comparison of GXQ Plume Depletion Factors to Slade (1968)

Case 2C: Same as Case 2A but with MACCS Building WakeDiscussion and Conclusion

This case tests the ability of GXQ to calculate a ground level release, centerline X/Q for each of the atmospheric stability classes (Pasquill A-G) at various wind speeds and distances using the MACCS computer code method to simulate the initial dispersion caused by building wake. Verification of correct solution of these equations is achieved by an independent spreadsheet calculation. Results agree to within two significant figures. The spreadsheet calculation and GXQ output file for this case follow.

Table 2C. Case 2C Hand Check (Building Wake Model)

Building Width =	40	m							
Building Height =	20	m							
2*pi =	6.283185								
F(y) =	1								
G(z) =	2								
Sigmay(0)	9.30e+00	m							
Sigmaz(0)	9.30e+00	m							

Atmos. Stab. Class	Wind Speed (m/s)	x (m)	Virt.y (m)	Virt.z (m)	x+Virt.y (m)	x+Virt.z (m)	Sigmay (m)	Sigmaz (m)	X/Q (1/m ³)
A	12	100	3.60e+01	6.32e+01	1.36e+02	1.63e+02	3.09e+01	2.23e+01	3.85e-05
B	8	1000	4.93e+01	8.43e+01	1.05e+03	1.08e+03	1.47e+02	1.20e+02	2.25e-06
C	4	10000	6.69e+01	1.27e+02	1.01e+04	1.01e+04	8.61e+02	5.04e+02	1.84e-07
D	6	100	9.87e+01	2.18e+02	1.99e+02	3.18e+02	1.75e+01	1.28e+01	2.37e-04
E	4	1000	1.44e+02	3.23e+02	1.14e+03	1.32e+03	6.05e+01	2.63e+01	5.01e-05
F	1	20000	2.17e+02	5.89e+02	2.02e+04	2.06e+04	5.59e+02	5.93e+01	9.61e-06
G	1	100	3.40e+02	1.15e+03	4.40e+02	1.25e+03	1.17e+01	9.96e+00	2.72e-03

WHC-SD-GN-SWD-30003 Rev 1

Current Input File Name: 2c.IN

GXQ Version 4.0
December 19, 1994

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

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Validation documented in WHC-SD-GN-SWD-3003 Rev. 1.
Code Custodian is Brit E. Hey, WHC, ext. 376-2921.

Run Date = 02/02/95
Run Time = 15:37:08.05

INPUT ECHO:

VV Case 2C: Virtual Source Building Wake (MACCS)

c mode
2

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F F F F

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
2 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 0

c PARAMETER INPUT:

c release	reference anemometer	mixing	frequency
c height	height	height	to
c (m)	(m)	(m)	exceed
			(%)
0.00000E+00	1.00000E+01	1.00000E+03	5.00000E+00

c initial	initial	release	deposition	gravitational
c plume	plume	duration	velocity	settling
c width	height	(hr)	(m/s)	velocity
c (m)	(m)			(m/s)
4.00000E+01	2.00000E+01	0.00000E+00	1.00000E-03	1.00000E-03

c ambient	initial	initial	release	convective
c temperature	plume	plume	diameter	heat release
c (C)	temperature	flow rate	(m)	rate(1)
	(C)	(m3/s)		(W)
2.00000E+01	2.20000E+01	1.00000E+00	1.00000E+00	0.00000E+00

c X/Q	Wind
c scaling	Speed
c factor	Exponent
c (?)	
1.00000E+00	7.80000E-01

c RECEPTOR DEPENDENT DATA (no line limit)

MODE:

X/Q calculated by stability class and wind speed.

LOGICAL CHOICES:

MODELS SELECTED:

MACCS Virtual source building wake model selected.
Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

VV Case 2C: Virtual Source Building Wake (MACCS)

ATM. STAB. CLASS	WIND SPEED (m/s)	DISTANCE (m)	OFFSET (m)	RECEPTOR HEIGHT (m)	SCALED X/Q (s/m ³)
A	12.00	100	0	0	3.85E-05
B	8.00	1000	0	0	2.25E-06
C	4.00	10000	0	0	1.84E-07
D	6.00	100	0	0	2.37E-04
E	4.00	1000	0	0	5.01E-05
F	1.00	20000	0	0	9.61E-06
G	1.00	100	0	0	2.74E-03

Case 2D: Same as Case 2A but with NRC (1982) Plume Meander and Building Wake

Discussion and Conclusion

This case tests the ability of GXQ to calculate a ground level release, centerline X/Q for each of the atmospheric stability classes (Pasquill A-G) at various wind speeds and distances with a correction applied to the horizontal diffusion coefficient to account for plume meander and building wake. The model used is taken from NRC (1982). Verification of correct solution of these equations is achieved by an independent spreadsheet calculation. Results to within two significant figures. The spreadsheet calculation and GXQ output file for this case follow.

Table 2D. Case 2D Check (NRC RG 1.145 Methodology)

Building Width =		40	m								
Building Height=		20	m								
2*pi =		6.28318									
F(y) =		1									
G(z) =		2									
Atmos.	Wind							[1]	[2]	[3]	
Stab.	Speed	x		Sy	Sy(800)	Syc	Sigmaz	X/Q	X/Q	X/Q	X/Q
Class	(m/s)	(m)	M	(m)	(m)	(m)	(m)	(1/m3)	(1/m3)	(1/m3)	(1/m3)
A	12	100	1	23.4	N/A	23.4	14.3	5.74e-05	2.64e-05	7.92e-05	5.74e-05
B	8	1000	1	140.9	N/A	140.9	110.2	2.54e-06	8.54e-07	2.56e-06	2.54e-06
C	4	10000	1	855.7	N/A	855.7	497.8	1.87e-07	6.23e-08	1.87e-07	1.87e-07
D	6	100	1	9.4	N/A	9.4	4.6	3.12e-04	4.12e-04	1.24e-03	4.12e-04
E	4	1000	1.5	53.6	43.8	75.5	21.5	6.22e-05	2.30e-05	4.90e-05	4.90e-05
F	1	20000	4	553.1	30.2	643.8	58.7	9.76e-06	3.27e-06	8.42e-06	8.42e-06
G	1	100	6	3.1	N/A	18.5	1.4	2.42e-03	2.53e-02	1.27e-02	1.27e-02

WHC-SD-GN-SWD-30003 Rev 1

Current Input File Name: 2d.IN

GXQ Version 4.0
December 19, 1994

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Westinghouse Hanford Company

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Code Custodian is Brit E. Hey, WHC, ext. 376-2921.

Run Date = 02/02/95
Run Time = 15:37:09.80

INPUT ECHO:

VV Case 2D: NRC RG 1.145 Plume Meander and Building Wake

c mode
2

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F F F F

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
1 1 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 0

c PARAMETER INPUT:

c	release	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)
c	0.00000E+00	1.00000E+01	1.00000E+03	5.00000E+00
c	initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)
c	4.00000E+01	2.00000E+01	0.00000E+00	1.00000E-03
c	ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	convective heat release rate(1) (w)
c	2.00000E+01	2.20000E+01	1.00000E+00	0.00000E+00
c	X/Q scaling factor (?)	Wind Speed Exponent		
c	1.00000E+00	7.80000E-01		

c RECEPTOR DEPENDENT DATA (no line limit)

MODE:

X/Q calculated by stability class and wind speed.

LOGICAL CHOICES:

MODELS SELECTED:

NRC RG 1.145 building wake model selected.

NRC RG 1.145 plume meander model selected.

Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

VV Case 2D: NRC RG 1.145 Plume Meander and Building Wake

ATM. STAB. CLASS	WIND SPEED (m/s)	DISTANCE (m)	OFFSET (m)	RECEPTOR HEIGHT (m)	SCALED X/Q (s/m ³)
A	12.00	100	0	0	5.74E-05
B	8.00	1000	0	0	2.54E-06
C	4.00	10000	0	0	1.87E-07
D	6.00	100	0	0	4.12E-04
E	4.00	1000	0	0	4.90E-05
F	1.00	20000	0	0	8.42E-06
G	1.00	100	0	0	1.27E-02

Case 2E: Same as Case 2A but with 5th Power Law Plume Meander

Discussion and Conclusion

This case tests the ability of GXQ to calculate a ground level release, centerline X/Q for each of the atmospheric stability classes (Pasquill A-G) at various wind speeds and distances with a correction applied to the horizontal diffusion coefficient to account for plume meander over time. The model used is commonly called the 5th power law. Verification of correct solution of these equations is achieved by an independent hand calculation. Results agree to within two significant figures. The hand calculation and GXQ output file for this case follow.

Table 2E. Case 2E Hand Check (5th Power Law)

Atm. Stab. Class	$\bar{U}$ (m/s)	x (m)	$\sigma_y^{(1)}$ (m)	$\sigma_{yc}^{(2)}$ (m)	$\sigma_z^{(1)}$ (m)	$\frac{x^{(3)}}{Q'}$ (s/m ³)
A	12	100	23.4	64.6	14.3	3.01×10^{-5}
B	8	1,000	141	371	110	9.75×10^{-7}
C	4	10,000	856	2253	498	7.09×10^{-8}
D	6	100	9.41	24.8	4.56	4.69×10^{-4}
E	4	1,000	53.6	141	21.5	2.63×10^{-5}
F	1	20,000	553	1,456	58.7	3.72×10^{-6}
G	1	100	3.08	8.11	1.36	2.89×10^{-2}

(1) From Case 2A calculated σ 's

(2)

$$\sigma_{yc} = \sigma_y \left(\frac{t_a}{10 \text{ min}} \right)^x$$

where:

$$t_a = 8 \text{ hrs} = 480 \text{ min}$$

$$x = 0.25$$

(3)

$$\frac{x}{Q'} = \frac{1}{\pi \sigma_{yc} \sigma_z \bar{U}}$$

Current Input File Name: 2e.IN

 GXQ Version 4.0
 December 19, 1994

General Purpose Atmospheric Dispersion Code
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 Westinghouse Hanford Company

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 Code Custodian is Brit E. Hey, WHC, ext. 376-2921.

Run Date = 02/02/95
 Run Time = 15:37:11.56

INPUT ECHO:

VV Case 2E: 1/5th Power Law Plume Meander

c mode
 2

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
 F F F F F F

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
 0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
 0 2 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
 0 0 0 0

c PARAMETER INPUT:

c release	reference anemometer	mixing	frequency to exceed
c height	height	height	(%)
c (m)	(m)	(m)	
0.00000E+00	1.00000E+01	1.00000E+03	5.00000E+00

c initial plume width	initial plume height	release duration	deposition velocity	gravitational settling velocity
c (m)	(m)	(hr)	(m/s)	(m/s)
4.00000E+01	2.00000E+01	8.00000E+00	1.00000E-03	1.00000E-03

c ambient temperature	initial plume temperature	initial plume flow rate	release diameter	convective heat release rate(1)
c (C)	(C)	(m3/s)	(m)	(w)
2.00000E+01	2.20000E+01	1.00000E+00	1.00000E+00	0.00000E+00

c X/Q scaling factor	Wind Speed Exponent
c (?)	
1.00000E+00	7.80000E-01

c RECEPTOR DEPENDENT DATA (no line limit)

MODE:

X/Q calculated by stability class and wind speed.

LOGICAL CHOICES:

MODELS SELECTED:

5th power law plume meander model selected.
Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

VV Case 2E: 1/5th Power Law Plume Meander

ATM. STAB. CLASS	WIND SPEED (m/s)	DISTANCE (m)	OFFSET (m)	RECEPTOR HEIGHT (m)	SCALED X/Q (s/m3)
A	12.00	100	0	0	3.01E-05
B	8.00	1000	0	0	9.74E-07
C	4.00	10000	0	0	7.10E-08
D	6.00	100	0	0	4.70E-04
E	4.00	1000	0	0	2.62E-05
F	1.00	20000	0	0	3.72E-06
G	1.00	100	0	0	2.89E-02

Case 2F: Same as Case 2A but with Sector Averaging

Discussion and Conclusion

This case tests the ability of GXQ to calculate a ground level release, sector average X/Q for each of the atmospheric stability classes (Pasquill A-G) at various wind speeds and distances. Verification of correct solution is achieved by an independent hand calculation. Results agree to within two significant figures. The hand calculation and GXQ output file for this case follow.

Table 2F. Case 2F Hand Check (Sector Average Model)

Atm. Stab. Class	$\bar{U}$ (m/s)	X (m)	$\sigma_z^{(1)}$ (m)	$\sigma_y^{(2)}$ (m)	$\frac{X^{(3)}}{Q'}$ (s/m ³)
A	12	100	14.3	15.7	1.18×10^{-4}
B	8	1,000	110	157	2.30×10^{-6}
C	4	10,000	498	1567	1.02×10^{-7}
D	6	100	4.56	15.7	7.43×10^{-4}
E	4	1,000	21.5	157	2.36×10^{-5}
F	1	20,000	58.7	3133	1.73×10^{-6}
G	1	100	1.36	15.7	1.49×10^{-2}

(1) From Case 2A calculated σ 's.

(2)

$$\sigma_y = \frac{x\sqrt{2\pi}}{16}$$

$$(3) \quad \frac{X}{Q'} = \frac{f(y) g(z)}{2\pi\sigma_y\sigma_z u}$$

where:

$$\begin{aligned} g(z) &= 2 && \text{(ground release)} \\ f(y) &= 1 && \text{(centerline)} \end{aligned}$$

WHC-SD-GN-SWD-30003 Rev 1

Current Input File Name: 2f.IN

GXQ Version 4.0
December 19, 1994

General Purpose Atmospheric Dispersion Code
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Westinghouse Hanford Company

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Code Custodian is Brit E. Hey, WHC, ext. 376-2921.

Run Date = 02/02/95
Run Time = 15:37:13.32

INPUT ECHO:

VV Case 2F: Sector Average

c mode
2

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F F F F

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 3 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 0

c

c PARAMETER INPUT:

c	release	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)
c	0.00000E+00	1.00000E+01	1.00000E+03	5.00000E+00

c	initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
c	4.00000E+01	2.00000E+01	0.00000E+00	1.00000E-03	1.00000E-03

c	ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (w)
c	2.00000E+01	2.20000E+01	1.00000E+00	1.00000E+00	0.00000E+00

c

c	X/Q scaling factor (?)	Wind Speed Exponent
c	1.00000E+00	7.80000E-01

c

c RECEPTOR DEPENDENT DATA (no line limit)

MODE:

X/Q calculated by stability class and wind speed.

LOGICAL CHOICES:

MODELS SELECTED:

Sector average model selected.

Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

VV Case 2F: Sector Average

ATM. STAB. CLASS	WIND SPEED (m/s)	DISTANCE (m)	OFFSET (m)	RECEPTOR HEIGHT (m)	SCALED X/Q (s/m ³)
A	12.00	100	0	0	1.18E-04
B	8.00	1000	0	0	2.30E-06
C	4.00	10000	0	0	1.02E-07
D	6.00	100	0	0	7.43E-04
E	4.00	1000	0	0	2.36E-05
F	1.00	20000	0	0	1.73E-06
G	1.00	100	0	0	1.49E-02

Case 2G: Same as Case 2A but Peak Air Concentration CalculatedDiscussion and Conclusion

This case tests the ability of GXQ to calculate a ground level release, peak air concentration X/Q for each of the atmospheric stability classes (Pasquill A-G) at various wind speeds. Verification of correct solution of this equation is achieved by an independent spreadsheet calculation. Results agree to within two significant figures. The spreadsheet calculation and GXQ output file for this case follow.

Table 2G. Case 2G Check (Peak Air Concentration)

$(2\pi)^{3/2} =$		15.74961			
$F(y) =$		1			
$G(z) =$		2			
Atmos. Stability Class	Wind Speed (m/s)	x (m)	Sigmay (m)	Sigmaz (m)	X/Q (1/m ³)
A	12	100	23.4	14.3	1.62e-05
B	8	1000	140.9	110.2	5.81e-08
C	4	10000	855.7	497.8	3.48e-10
D	6	100	9.4	4.6	3.14e-04
E	4	1000	53.6	21.5	2.06e-06
F	1	20000	553.1	58.7	7.07e-09
G	1	100	3.1	1.4	9.85e-03

WHC-SD-GN-SWD-30003 Rev 1

Current Input File Name: 2g.IN

GXQ Version 4.0
December 19, 1994

General Purpose Atmospheric Dispersion Code
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Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 1.
Code Custodian is Brit E. Hey, WHC, ext. 376-2921.

Run Date = 02/02/95
Run Time = 15:37:15.08

INPUT ECHO:

VV Case 2G: Peak Air Concentration

c mode
2

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F F F F

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
1 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 0

c PARAMETER INPUT:

c release	reference		frequency
c height	anemometer	mixing	to
c (m)	height	height	exceed
	(m)	(m)	(%)
0.00000E+00	1.00000E+01	1.00000E+03	5.00000E+00

c initial	initial		deposition	gravitational
c plume	plume	release	velocity	settling
c width	height	duration	(m/s)	velocity
c (m)	(m)	(hr)		(m/s)
4.00000E+01	2.00000E+01	0.00000E+00	1.00000E-03	1.00000E-03

c ambient	initial	initial	release	convective
c temperature	plume	plume	diameter	heat release
c (C)	temperature	flow rate	(m)	rate(1)
	(C)	(m3/s)		(w)
2.00000E+01	2.20000E+01	1.00000E+00	1.00000E+00	0.00000E+00

c X/Q	
c scaling	Wind
c factor	Speed
c (?)	Exponent
1.00000E+00	7.80000E-01

c RECEPTOR DEPENDENT DATA (no line limit)

MODE:

X/Q calculated by stability class and wind speed.

LOGICAL CHOICES:

MODELS SELECTED:

Gaussian puff model selected.

WARNING/ERROR MESSAGES:

VV Case 2G: Peak Air Concentration

ATM. STAB. CLASS	WIND SPEED (m/s)	DISTANCE (m)	OFFSET (m)	RECEPTOR HEIGHT (m)	SCALED X/Q (1/m3)
A	12.00	100	0	0	1.62E-05
B	8.00	1000	0	0	5.81E-08
C	4.00	10000	0	0	3.49E-10
D	6.00	100	0	0	3.14E-04
E	4.00	1000	0	0	2.06E-06
F	1.00	20000	0	0	7.07E-09
G	1.00	100	0	0	9.85E-03

Case 2H1: Same as Case 2A but with MACCS Plume Rise and Downwash

Discussion and Conclusion

This case tests the GXQ implementation of the MACCS code procedure for applying buoyancy plume rise in the calculation of a ground level release, centerline X/Q for each of the atmospheric stability classes (Pasquill A-G) at various wind speeds and distances. Additionally, the Mills' adjustment, stack downwash, gravitational settling, entrainment, and wind adjustment models discussed in the GXQ Users' Guide (Hey 1994) are also checked using this test case. Verification of correct solution of these equations is achieved by an independent calculation using a computer spreadsheet. Even though the spreadsheet is somewhat simplified, results agree to within two significant figures. The spreadsheet results, GXQ input file and GXQ calculated effective release heights for this case follow.

Table 2H1. Case 2H1 Spreadsheet Check of MACCS Plume Rise Model

Table 2H1. Case 2H1, MACCS Plume Rise w/ Mills' Adjustment, Wind Adjustment, Stack Downwash, Gravitational Settling, and Entrainment

Tamb =	293	K	
T0 =	293	K	
dstack =	10	m	
V0 =	125	m3/s	
w0 =	1.5915495	m/s	(4.3-2)
qh =	5.00E+6	w	
Vg =	0.001	m/s	
Bb =	0.6		
Fb =	43.95	m4/s3	(4.3-1)
Rb (buoyancy) =	0.3470573		(4.3-26)

First Order Plume Rise Calculation

GXQ Users' Guide Equation Numbers -										4.3-26	4.3-7	4.3-8A,B	4.3-8C	4.3-25	4.3-27	4.3-26			
4.1-15												first buoy. rise limit	second buoy. rise limit	min. buoy. rise limit	allowed buoy. rise	Mills' modified rise	grav. settling	down wash	net plume rise
class	heff	p	us	ueff	uavg	x	Rm	buoy. rise	stability param.										
a	0.0	0.07	12.0	12.0	12.0	100	0.13	10.2			7.6	581.9	7.6	7.6	1.7	0.0	23.06	0.0	
b	0.0	0.07	8.0	8.0	8.0	1000	0.20	71.0			25.8	666.1	25.8	25.8	17.7	0.1	23.06	0.0	
c	0.0	0.10	4.0	4.0	4.0	10000	0.40	658.5			206.0	839.2	206.0	206.0	197.6	2.5	22.04	173.0	
d	0.0	0.15	6.0	6.0	6.0	100	0.27	20.4			61.0	733.1	61.0	20.4	12.5	0.0	23.06	0.0	
e	0.0	0.35	4.0	4.0	4.0	1000	0.40	141.9	4.95E-4		73.0	839.2	73.0	73.0	64.7	0.3	22.04	42.4	
f	0.0	0.55	1.0	1.0	1.0	20000	1.59	4180.6	1.25E-3		85.2	1332.0	85.2	85.2	76.9	20.0	0.00	56.9	
g	0.0	0.60	1.0	1.0	1.0	100	1.59	122.3	2.42E-3		68.3	1332.0	68.3	68.3	60.0	0.1	0.00	59.9	

Second Order Plume Rise Calculation

GXQ Users' Guide Equation Numbers -										4.3-26	4.3-7	4.3-8A,B	4.3-8C	4.3-25	4.3-27	4.3-26			
4.1-15												first buoy. rise limit	second buoy. rise limit	min. buoy. rise limit	allowed buoy. rise	Mills' modified rise	grav. settling	down wash	net plume rise
class	heff	p	us	ueff	uavg	x	R	buoy rise	stability param.		rise limit	rise limit	rise limit	rise	rise	rise	rise	rise	rise
a	0.0	0.07	12.0	12.0	12.0	100	0.13	10.2			7.6	581.9	7.6	7.6	1.7	0.0	23.06	0.0	
b	0.0	0.07	8.0	8.0	8.0	1000	0.20	71.0			25.8	666.1	25.8	25.8	17.7	0.1	23.06	0.0	
c	173.0	0.10	4.0	5.3	4.7	10000	0.34	565.3			130.3	797.5	130.3	130.3	121.9	2.1	22.04	97.7	
d	0.0	0.15	6.0	6.0	6.0	100	0.27	20.4			61.0	733.1	61.0	20.4	12.5	0.0	23.06	0.0	
e	42.4	0.35	4.0	6.6	5.3	1000	0.30	106.8	4.95E-4		66.4	763.2	66.4	66.4	58.1	0.2	22.04	35.9	
f	56.9	0.55	1.0	2.6	1.8	20000	0.88	2322.1	1.25E-3		70.0	1094.9	70.0	70.0	61.7	11.1	0.00	50.6	
g	59.9	0.60	1.0	2.9	2.0	100	0.81	62.3	2.42E-3		54.6	1063.7	54.6	54.6	46.3	0.1	0.00	46.2	

Third Order Plume Rise Calculation

GXQ Users' Guide Equation Numbers -										4.3-26	4.3-7	4.3-8A,B	4.3-8C	4.3-25	4.3-27	4.3-26			
4.1-15												first buoy. rise limit	second buoy. rise limit	min. buoy. rise limit	allowed buoy. rise	Mills' modified rise	grav. settling	down wash	net plume rise
class	heff	p	us	ueff	uavg	x	R	buoy rise	stability param.										
a	0.0	0.07	12.0	12.0	12.0	100	0.13	10.2			7.6	581.9	7.6	7.6	1.7	0.0	23.06	0.0	
b	0.0	0.07	8.0	8.0	8.0	1000	0.20	71.0			25.8	666.1	25.8	25.8	17.7	0.1	23.06	0.0	
c	97.7	0.10	4.0	5.0	4.5	10000	0.35	583.8			143.5	806.1	143.5	143.5	135.1	2.2	22.04	110.9	
d	0.0	0.15	6.0	6.0	6.0	100	0.27	20.4			61.0	733.1	61.0	20.4	12.5	0.0	23.06	0.0	
e	35.9	0.35	4.0	6.3	5.1	1000	0.31	110.7	4.95E-4		67.2	772.5	67.2	67.2	58.9	0.2	22.04	36.7	
f	50.6	0.55	1.0	2.4	1.7	20000	0.93	2431.0	1.25E-3		71.1	1111.8	71.1	71.1	62.8	11.6	0.00	51.2	
g	46.2	0.60	1.0	2.5	1.8	100	0.91	69.8	2.42E-3		56.7	1104.7	56.7	56.7	48.4	0.1	0.00	48.3	

Fourth Order Plume Rise Calculation

Fourth Order Plume Rise Calculation										4.3-26	4.3-7	4.3-8A,B	4.3-8C	4.3-25	4.3-27	4.3-26			
GXQ Users' Guide Equation Numbers -																			
4.1-15												first buoy. rise limit	second buoy. rise limit	min. buoy. rise limit	allowed buoy. rise	Mills' modified rise	grav. settling	down wash	net plume rise
class	heff	p	us	ueff	uavg	x	R	buoy rise	stability param.										
a	0.0	0.07	12.0	12.0	12.0	100	0.13	10.2			7.6	581.9	7.6	7.6	1.7	0.0	23.06	0.0	
b	0.0	0.07	8.0	8.0	8.0	1000	0.20	71.0			25.8	666.1	25.8	25.8	17.7	0.1	23.06	0.0	
c	110.9	0.10	4.0	5.1	4.5	10000	0.35	579.7			140.5	804.2	140.5	140.5	132.1	2.2	22.04	107.9	
d	0.0	0.15	6.0	6.0	6.0	100	0.27	20.4			61.0	733.1	61.0	20.4	12.5	0.0	23.06	0.0	
e	36.7	0.35	4.0	6.3	5.2	1000	0.31	110.2	4.95E-4		67.1	771.3	67.1	67.1	58.8	0.2	22.04	36.6	
f	51.2	0.55	1.0	2.5	1.7	20000	0.92	2420.7	1.25E-3		71.0	1110.2	71.0	71.0	62.7	11.6	0.00	51.1	
g	48.3	0.60	1.0	2.6	1.8	100	0.89	68.4	2.42E-3		56.3	1097.7	56.3	56.3	48.0	0.1	0.00	48.0	

Fifth Order Plume Rise Calculation

GXQ Users' Guide Equation Numbers -								4.3-26	4.3-7	4.3-8A,B	4.3-8C	4.3-25	4.3-27	4.3-26			
4.1-15										first	second	min.					
								buoy	stability	rise	rise	rise	allowed	Mills'	grav.	down	net
class	heff	p	us	ueff	uavg	x	R	rise	param.	limit	limit	limit	rise	rise	settling	wash	plume
a	0.0	0.07	12.0	12.0	12.0	100	0.13	10.2		7.6	581.9	7.6	7.6	1.7	0.0	23.06	0.0
b	0.0	0.07	8.0	8.0	8.0	1000	0.20	71.0		25.8	666.1	25.8	25.8	17.7	0.1	23.06	0.0
c	107.9	0.10	4.0	5.1	4.5	10000	0.35	580.6		141.2	804.6	141.2	141.2	132.8	2.2	22.04	108.5
d	0.0	0.15	6.0	6.0	6.0	100	0.27	20.4		61.0	733.1	61.0	20.4	12.5	0.0	23.06	0.0
e	36.6	0.35	4.0	6.3	5.1	1000	0.31	110.2	4.95E-4	67.1	771.4	67.1	67.1	58.8	0.2	22.04	36.6
f	51.1	0.55	1.0	2.5	1.7	20000	0.92	2421.6	1.25E-3	71.0	1110.4	71.0	71.0	62.7	11.6	0.00	51.1
g	48.0	0.60	1.0	2.6	1.8	100	0.89	68.7	2.42E-3	56.4	1098.9	56.4	56.4	48.1	0.1	0.00	48.0

Atmospheric Dispersion Calculation

class	heff	p	us	ueff	uavg	sy	sz	Sy	Sz	x/q
a	0.0	0.07	12.0	12.0	12.0	23.4	14.3	23.4	14.3	7.93E-5
b	0.0	0.07	8.0	8.0	8.0	141.0	110.0	141.0	110.0	2.57E-6
c	108.5	0.10	4.0	5.1	4.5	856.0	498.0	856.6	499.0	1.60E-7
d	0.0	0.15	6.0	6.0	6.0	9.4	4.6	9.4	4.6	1.24E-3
e	36.6	0.35	4.0	6.3	5.1	53.6	21.5	54.6	23.9	1.47E-5
f	51.1	0.55	1.0	2.5	1.7	553.0	58.7	553.2	60.5	3.86E-6
g	48.0	0.60	1.0	2.6	1.8	3.1	1.4	14.1	13.8	2.14E-6

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VV Case 2H1: MACCS Plume Rise w/ Mills Adj., Downwash, Gravity, Entr. and Wind

c mode
2

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F t F F

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 1

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 1

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
1 1 1 1

c

c PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)
0	10	1000	5

c

initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
0	0	0	0.001	0.001

c

ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m ³ /s)	release diameter (m)	convective heat release rate(1) (w)
20	748	125	10	5.00E+6

c

X/Q scaling factor (?)	Wind Speed Exponent
1	.78

c RECEPTOR DEPENDENT DATA (no line limit)

1	12	100	0	0
2	8	1000	0	0
3	4	10000	0	0
4	6	100	0	0
5	4	1000	0	0
6	1	20000	0	0
7	1	100	0	0

----- 2H1.OUT

effective release height (he)	=	0.000000	m
effective release height (he)	=	0.000000	m
effective release height (he)	=	108.571	m
effective release height (he)	=	0.000000	m
effective release height (he)	=	36.7245	m
effective release height (he)	=	51.2064	m
effective release height (he)	=	47.9975	m

Case 2H2A: Same as Case 2A but with ISC2 Plume Rise w/ $\Delta T = -3.66\text{ }^{\circ}\text{C}$

Discussion and Conclusion

This case tests the GXQ implementation of the ISC2 code procedure for calculating momentum and buoyancy plume rise. The effective release height for each of the atmospheric stability classes (Pasquill A-G) at various wind speeds and distances are calculated. No wind adjustment and therefore, no iteration is necessary. Plume rise is based on a $\Delta T = -3.66\text{ }^{\circ}\text{C}$ in order to test the momentum rise model. Verification of correct solution of these equations is achieved by an independent calculation using a computer spreadsheet. Results agree to within two significant figures. The spreadsheet and GXQ input file and calculated effective release heights for this case follow.

Table 2H2A. Case 2H2A Check (ISC2 Plume Rise w/ $\Delta T = -3.66^\circ\text{C}$)

Table 2H2A. Case 2H2A, ISC2 Plume Rise

Tamb =	293 K	dstack =	5 m
T0 =	289.733238 K	V0 =	125 m ³ /s
delta T =	-3.2667624 K	w0 =	6.36619783 m/s
Cp0 =	1005 J/(kg K)		
rho0 =	1.21836211 kg/m ³		
qh =	-5.00E+5 W		
Fb =	-4.395 m ⁴ /s ³	-4.3964835 (4.3-3)	
Fm =	256.158976 m ⁴ /s ²	(4.3-5)	

Plume Rise Calculation

GXQ Users' Guide Equation Numbers -											
			4.3-10,11	4.3-12,13	4.3-7	4.3-21	4.3-24	4.3-20	4.3-16		
class	ueff	x	stability param. s	crossover temp. difference	distance to final buoyant rise	buoyant rise	momen. xmax	jet entrain. beta m	distance dependent momen. rise	final plume momen. rise	plume rise
a	12.0	100	0.0	5.5	#NUM!	#NUM!	469.9	2.2	4.8	8.0	4.8
b	8.0	1000	0.0	5.5	#NUM!	#NUM!	362.1	1.6	12.0	11.9	11.9
c	4.0	10000	0.0	5.5	#NUM!	#NUM!	264.9	1.0	24.0	23.9	23.9
d	6.0	100	0.0	5.5	#NUM!	#NUM!	310.9	1.3	10.9	15.9	10.9
equations:			4.3-6	4.3-17	4.3-18	4.3-7	4.3-23	4.3-24	4.3-22	4.3-16,19	
e	4.0	1000	4.95E-4	0.8	372.4	#NUM!	282.4	1.0	21.1	21.3	21.1
f	1.0	20000	1.25E-3	1.3	58.6	#NUM!	44.5	0.5	44.9	29.0	29.0
g	1.0	100	2.42E-3	1.8	42.1	#NUM!	31.9	0.5	40.2	26.0	26.0

Atmospheric Dispersion Calculation

		4.1-4	4.2-1	4.2-2	4.1-1	
class	ueff	x	heff	sy	sz	x/q
a	12.0	100	4.8	23.4	14.3	7.49E-5
b	8.0	1000	11.9	140.9	110.2	2.55E-6
c	4.0	10000	23.9	855.7	497.8	1.87E-7
d	6.0	100	10.9	9.4	4.6	6.92E-5
e	4.0	1000	21.1	53.6	21.3	4.28E-5
f	1.0	20000	29.0	553.1	58.7	8.67E-6
g	1.0	100	26.0	3.1	1.4	3.91E-81

VV Case 2H2A: ISC2 Plume Rise

c mode
2

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F T F F

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
2 0 0 0

c

c PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)		
0	10	1000	5		
initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)	
0	0	0	0.001	0.001	
ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (W)	
20	16.734	125	5	0	
X/Q scaling factor (?)	Wind Speed Exponent				
1	.78				

c

c RECEPTOR DEPENDENT DATA (no line limit)

1	12	100	0	0
2	8	1000	0	0
3	4	10000	0	0
4	6	100	0	0
5	4	1000	0	0
6	1	20000	0	0
7	1	100	0	0

----- 2H2A.OUT

effective release height (he)	=	4.76881	m
effective release height (he)	=	11.9366	m
effective release height (he)	=	23.8732	m
effective release height (he)	=	10.9459	m
effective release height (he)	=	21.0575	m
effective release height (he)	=	29.0345	m
effective release height (he)	=	26.0022	m

Case 2H2B: Same as Case 2A but with ISC2 Plume Rise w/ $\Delta T = 3\text{ }^{\circ}\text{C}$

Discussion and Conclusion

This case tests the GXQ implementation of the ISC2 code procedure for calculating momentum and buoyancy plume rise. The effective release height for each of the atmospheric stability classes (Pasquill A-G) at various wind speeds and distances are calculated. No wind adjustment and therefore, no iteration is necessary. Plume rise is based on a $\Delta T = 3\text{ }^{\circ}\text{C}$ in order to test the crossover point between the momentum and buoyancy rise model. Verification of correct solution of these equations is achieved by an independent calculation using a computer spreadsheet. Results agree to within two significant figures. The spreadsheet and GXQ input file and calculated effective release heights for this case follow.

Table 2H2B. Case 2H2B Check (ISC2 Plume Rise w/ $\Delta T = 3^\circ\text{C}$)

Table 2H2B. Case 2H2B, ISC2 Plume Rise

Tamb =	293	K	dstack =	5	m
T0 =	296	K	v0 =	125	m ³ /s
delta T =	3	K	w0 =	6.36619783	m/s
Cp0 =	1005	J/(kg K)			
rho0 =	1.19256757	kg/m ³			
qh =	0.00E+0	W			
Fb =	3.95198936	m ⁴ /s ³	3.95198936	(4.3-3)	
Fm =	250.735708	m ⁴ /s ²		(4.3-5)	

Plume Rise Calculation

GXQ Users' Guide Equation Numbers -												
			4.3-10,11	4.3-12,13	4.3-7	4.3-21	4.3-24	4.3-20	4.3-16			
class	ueff	x	stability param. s	crossover temp. difference	distance to final buoyant rise	buoyant rise	momen. xmax	jet entrain. beta m	distance dependent momen. rise	final plume momen. rise	plume rise	
a	12.0	100	0.0	5.6	115.7	4.5	115.7	2.2	4.7	8.0	4.7	
b	8.0	1000	0.0	5.6	115.7	7.5	115.7	1.6	8.1	11.9	8.1	
c	4.0	10000	0.0	5.6	115.7	15.0	115.7	1.0	18.0	23.9	18.0	
d	6.0	100	0.0	5.6	115.7	9.1	115.7	1.3	10.9	15.9	10.9	
equations:			4.3-6	4.3-17	4.3-18	4.3-7	4.3-23	4.3-24	4.3-22	4.3-16,19		
e	4.0	1000	4.95E-4	0.8	372.4	32.7	282.4	1.0	20.9	21.2	32.7	
f	1.0	20000	1.25E-3	1.3	58.6	38.2	44.5	0.5	44.6	28.8	38.2	
g	1.0	100	2.42E-3	1.8	42.1	30.6	31.9	0.5	39.9	25.8	30.6	

Atmospheric Dispersion Calculation

			4.1-4	4.2-1	4.2-2	4.1-1
class	ueff	x	heff	sy	sz	x/q
a	12.0	100	4.7	23.4	14.3	7.50E-5
b	8.0	1000	8.1	140.9	110.2	2.56E-6
c	4.0	10000	18.0	855.7	497.8	1.87E-7
d	6.0	100	10.9	9.4	4.6	7.20E-5
e	4.0	1000	32.7	53.6	21.3	2.15E-5
f	1.0	20000	38.2	553.1	58.7	7.93E-6
g	1.0	100	30.6	3.1	1.4	6.46E-112

VV Case 2H2B: ISC2 Plume Rise

c mode
2

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F T F F

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
2 0 0 0

c

c PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)
0	10	1000	5

c

initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
0	0	0	0.001	0.001

c

ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (w)
20	23	125	5	0

c

X/Q scaling factor (?)	Wind Speed Exponent
1	.78

c

c RECEPTOR DEPENDENT DATA (no line limit)

1	12	100	0	0
2	8	1000	0	0
3	4	10000	0	0
4	6	100	0	0
5	4	1000	0	0
6	1	20000	0	0
7	1	100	0	0

----- 2H2B.OUT

effective release height (he)	=	4.73492	m
effective release height (he)	=	11.8961	m
effective release height (he)	=	23.7922	m
effective release height (he)	=	10.8681	m
effective release height (he)	=	32.7432	m
effective release height (he)	=	38.1937	m
effective release height (he)	=	30.6325	m

Case 2H2C: Same as Case 2A but with ISC2 Plume Rise w/ $\Delta T = 57\text{ }^{\circ}\text{C}$

Discussion and Conclusion

This case tests the GXQ implementation of the ISC2 code procedure for calculating momentum and buoyancy plume rise. The effective release height for each of the atmospheric stability classes (Pasquill A-G) at various wind speeds and distances are calculated. No wind adjustment and therefore, no iteration is necessary. Plume rise is based on a $\Delta T = 57\text{ }^{\circ}\text{C}$ in order to test the buoyancy rise model based on a temperature difference and a buoyancy flux $> 55\text{ m}^4/\text{s}^3$. Verification of correct solution of these equations is achieved by an independent calculation using a computer spreadsheet. Results agree to within two significant figures. The spreadsheet and GXQ input file and calculated effective release heights for this case follow.

Table 2H2C. Case 2H2C Check (ISC2 Plume Rise w/ $\Delta T = 57^\circ\text{C}$)

Table 2H2C. Case 2H2C, ISC2 Plume Rise

Tamb =	293	K	dstack =	5	m
T0 =	350	K	v0 =	125	m3/s
delta T =	57	K	w0 =	6.36619783	m/s
Cp0 =	1005	J/(kg K)			
rho0 =	1.00857143	kg/m3			
qh =	0.00E+0	w			
Fb =	63.5028234	m4/s3	63.5028234	(4.3-3)	
Fm =	212.05077	m4/s2		(4.3-5)	

Plume Rise Calculation

GXQ Users' Guide Equation Numbers -											
class	ueff	x	stability param. s	crossover temp. difference	distance to final buoyant rise	buoyant rise	momen. xmax	jet entrain. beta m	distance dependent momen. rise	final plume momen. rise	plume rise
a	12.0	100	0.0	1.4	626.1	11.5	626.1	2.2	4.5	8.0	11.5
b	8.0	1000	0.0	1.4	626.1	58.4	626.1	1.6	13.5	11.9	58.4
c	4.0	10000	0.0	1.4	626.1	116.8	626.1	1.0	30.0	23.9	116.8
d	6.0	100	0.0	1.4	626.1	22.9	626.1	1.3	10.3	15.9	22.9
equations:			4.3-6	4.3-17	4.3-18	4.3-7	4.3-23	4.3-24	4.3-22	4.3-16,19	
e	4.0	1000	4.95E-4	1.0	372.4	82.6	282.4	1.0	19.8	20.0	82.6
f	1.0	20000	1.25E-3	1.5	58.6	96.4	44.5	0.5	42.1	27.3	96.4
g	1.0	100	2.42E-3	2.1	42.1	77.3	31.9	0.5	37.7	24.4	77.3

Atmospheric Dispersion Calculation

class	ueff	x	heff	sy	sz	x/q
a	12.0	100	11.5	23.4	14.3	5.75E-5
b	8.0	1000	58.4	140.9	110.2	2.23E-6
c	4.0	10000	116.8	855.7	497.8	1.82E-7
d	6.0	100	22.9	9.4	4.6	3.96E-9
e	4.0	1000	82.6	53.6	21.3	3.87E-8
f	1.0	20000	96.4	553.1	58.7	2.55E-6
g	1.0	100	77.3	3.1	1.4	0.00E+0

VV Case 2H2C: ISC2 Plume Rise

c mode

2

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop

F F F T F F

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind

0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr

0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav

2 0 0 0

c

c PARAMETER INPUT:

c release reference frequency

c height anemometer to

c (m) height height exceed

c (m) (m) (m) (%)

c 0 10 1000 5

c

c initial initial gravitational

c plume plume settling

c width height release deposition

c (m) (m) duration velocity velocity

c (m) (m) (hr) (m/s) (m/s)

c 0 0 0 0.001 0.001

c

c ambient initial convective

c temperature plume heat release

c (C) temperature flow rate diameter rate(1)

c (C) (C) (m3/s) (m) (w)

c 20 77 125 5 0

c

c X/Q

c scaling Wind

c factor Speed

c (?) Exponent

c 1 .78

c

c RECEPTOR DEPENDENT DATA (no line limit)

1 12 100 0 0

2 8 1000 0 0

3 4 10000 0 0

4 6 100 0 0

5 4 1000 0 0

6 1 20000 0 0

7 1 100 0 0

----- 2H2C.OUT

effective release height (he) = 11.4632 m

effective release height (he) = 58.4245 m

effective release height (he) = 116.849 m

effective release height (he) = 22.9264 m

effective release height (he) = 82.6252 m

effective release height (he) = 96.3793 m

effective release height (he) = 77.2990 m

Case 2H2D: Same as Case 2A but with ISC2 Plume Rise w/ $q_h = 1.0E+5$ w

Discussion and Conclusion

This case tests the GXQ implementation of the ISC2 code procedure for calculating momentum and buoyancy plume rise. The effective release height for each of the atmospheric stability classes (Pasquill A-G) at various wind speeds and distances are calculated. No wind adjustment and therefore, no iteration is necessary. Plume rise is based on a $q_h = 1.0E+5$ w in order to test the momentum and buoyancy rise model based on low convective heat input and a low buoyancy flux. Verification of correct solution of these equations is achieved by an independent calculation using a computer spreadsheet. Results agree to within two significant figures. The spreadsheet and GXQ input file and calculated effective release heights for this case follow.

Table 2H2D. Case 2H2D Check (ISC2 Plume Rise w/ $q_h = 1.0E+5$ W)

Table 2H2D. Case 2H2D, ISC2 Plume Rise

Tamb =	293 K	dstack =	5 m
T0 =	293.662212 K	V0 =	125 m ³ /s
delta T =	0.66221237 K	w0 =	6.36619783 m/s
Cp0 =	1005 J/(kg K)		
rho0 =	1.20206137 kg/m ³		
qh =	1.00E+5 W		
Fb =	0.879 m ⁴ /s ³	0.8792967 (4.3-3)	
Fm =	252.731766 m ⁴ /s ²	(4.3-5)	

Plume Rise Calculation

GXQ Users' Guide Equation Numbers -												
				4.3-10,11	4.3-12,13	4.3-7	4.3-21	4.3-24	4.3-20	4.3-16		
class	ueff	x	stability param. s	crossover temp. difference	distance to final buoyant rise	buoyant rise	momen. xmax	jet entrain. beta m	distance dependent momen. rise	final plume momen. rise	plume rise	
a	12.0	100	0.0	5.5	45.2	1.6	45.2	2.2	3.6	8.0	3.6	
b	8.0	1000	0.0	5.5	45.2	2.4	45.2	1.6	6.0	11.9	6.0	
c	4.0	10000	0.0	5.5	45.2	4.9	45.2	1.0	13.2	23.9	13.2	
d	6.0	100	0.0	5.5	45.2	3.2	45.2	1.3	8.4	15.9	8.4	
equations:				4.3-6	4.3-17	4.3-18	4.3-7	4.3-23	4.3-24	4.3-22	4.3-16,19	
e	4.0	1000	4.95E-4	0.8	372.4	19.8	282.4	1.0	21.0	21.2	21.0	
f	1.0	20000	1.25E-3	1.3	58.6	23.1	44.5	0.5	44.7	28.9	28.9	
g	1.0	100	2.42E-3	1.8	42.1	18.6	31.9	0.5	40.0	25.9	25.9	

Atmospheric Dispersion Calculation

class	ueff	x	heff	sy	sz	x/q
a	12.0	100	3.6	23.4	14.3	7.67E-5
b	8.0	1000	6.0	140.9	110.2	2.56E-6
c	4.0	10000	13.2	855.7	497.8	1.87E-7
d	6.0	100	8.4	9.4	4.6	2.30E-4
e	4.0	1000	21.0	53.6	21.3	4.30E-5
f	1.0	20000	28.9	553.1	58.7	8.68E-6
g	1.0	100	25.9	3.1	1.4	2.00E-80

VV Case 2H2D: ISC2 Plume Rise

c mode

2

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop

F F F T F F

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind

0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr

0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav

2 0 0 0

c

c PARAMETER INPUT:

c release reference frequency

c height anemometer to

c (m) height height exceed

c 0 10 1000 5

c

c initial initial

c plume plume release deposition

c width height duration velocity

c (m) (m) (hr) (m/s)

c 0 0 0 0.001

c

c ambient initial

c temperature plume release

c (C) temperature flow rate diameter

c 20 20.66 125 5

c

c X/Q initial

c scaling plume convective

c factor Wind heat release

c (?) Speed rate(1)

c 1 .78 1E+5

c

c RECEPTOR DEPENDENT DATA (no line limit)

1 12 100 0 0

2 8 1000 0 0

3 4 10000 0 0

4 6 100 0 0

5 4 1000 0 0

6 1 20000 0 0

7 1 100 0 0

Case 2H2E: Same as Case 2A but with ISC2 Plume Rise w/ $q_h = 1.0E+6$ w

Discussion and Conclusion

This case tests the GXQ implementation of the ISC2 code procedure for calculating momentum and buoyancy plume rise. The effective release height for each of the atmospheric stability classes (Pasquill A-G) at various wind speeds and distances are calculated. No wind adjustment and therefore, no iteration is necessary. Plume rise is based on a $q_h = 1.0E+6$ w in order to test the buoyancy rise model based on convective heat input and a low buoyancy flux. Verification of correct solution of these equations is achieved by an independent calculation using a computer spreadsheet. Results agree to within two significant figures. The spreadsheet and GXQ input file and calculated effective release heights for this case follow.

Table 2H2E. Case 2H2E Check (ISC2 Plume Rise w/ $q_h = 1.0E+6$ w)

Table 2H2E. Case 2H2E, ISC2 Plume Rise

Tamb = 293 K dstack = 5 m
 T0 = 299.759621 K 0 v0 = 125 m³/s
 delta T = 6.75962107 K w0 = 6.36619783 m/s
 Cp0 = 1005 J/(kg K)
 rho0 = 1.17761024 kg/m³
 qh = 1.00E+6 w
 Fb = 8.79 m⁴/s³ 8.792967 (4.3-3)
 Fm = 247.590951 m⁴/s² (4.3-5)

Plume Rise Calculation

GXQ Users' Guide Equation Numbers -											
			4.3-10,11	4.3-12,13	4.3-7	4.3-21	4.3-24	4.3-20	4.3-16		
class	ueff	x	stability param. s	crossover temp. difference	distance to final buoyant rise	buoyant rise	momen. xmax	jet entrain. beta m	distance dependent momen. rise	final plume momen. rise	plume rise
a	12.0	100	0.0	5.6	190.6	5.9	190.6	2.2	4.7	8.0	5.9
b	8.0	1000	0.0	5.6	190.6	13.7	190.6	1.6	9.6	11.9	13.7
c	4.0	10000	0.0	5.6	190.6	27.3	190.6	1.0	21.2	23.9	27.3
d	6.0	100	0.0	5.6	190.6	11.9	190.6	1.3	10.8	15.9	11.9
equations:			4.3-6	4.3-17	4.3-18	4.3-7	4.3-23	4.3-24	4.3-22	4.3-16,19	
e	4.0	1000	4.95E-4	0.8	372.4	42.7	282.4	1.0	20.8	21.1	42.7
f	1.0	20000	1.25E-3	1.3	58.6	49.8	44.5	0.5	44.4	28.7	49.8
g	1.0	100	2.42E-3	1.8	42.1	40.0	31.9	0.5	39.7	25.7	40.0

Atmospheric Dispersion Calculation

			4.1-4	4.2-1	4.2-2	4.1-1
class	ueff	x	heff	sy	sz	x/q
a	12.0	100	5.9	23.4	14.3	7.27E-5
b	8.0	1000	13.7	140.9	110.2	2.54E-6
c	4.0	10000	27.3	855.7	497.8	1.87E-7
d	6.0	100	11.9	9.4	4.6	4.19E-5
e	4.0	1000	42.7	53.6	21.3	9.37E-6
f	1.0	20000	49.8	553.1	58.7	6.84E-6
g	1.0	100	40.0	3.1	1.4	2.19E-189

VV Case 2H2E: ISC2 Plume Rise

c mode
2

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F T F F

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
2 0 0 0

c

c PARAMETER INPUT:

c	release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)	
c	0	10	1000	5	
c	initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
c	0	0	0	0.001	0.001
c	ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (W)
c	20	26.76	125	5	1E+6
c	X/Q scaling factor (?)	Wind Speed Exponent			
c	1	.78			

c

c RECEPTOR DEPENDENT DATA (no line limit)

1	12	100	0	0
2	8	1000	0	0
3	4	10000	0	0
4	6	100	0	0
5	4	1000	0	0
6	1	20000	0	0
7	1	100	0	0

----- 2H2E.OUT

effective release height (he)	=	5.92801	m
effective release height (he)	=	13.6698	m
effective release height (he)	=	27.3397	m
effective release height (he)	=	11.8560	m
effective release height (he)	=	42.7283	m
effective release height (he)	=	49.8409	m
effective release height (he)	=	39.9739	m

Case 2H2F: Same as Case 2A but with ISC2 Plume Rise w/ $q_h = 5.0E+6$ w

Discussion and Conclusion

This case tests the GXQ implementation of the ISC2 code procedure for calculating momentum and buoyancy plume rise. The effective release height for each of the atmospheric stability classes (Pasquill A-G) at various wind speeds and distances are calculated. No wind adjustment and therefore, no iteration is necessary. Plume rise is based on a $q_h = 5.0E+6$ w in order to test the buoyancy rise model based on convective heat input and a medium buoyancy flux. Verification of correct solution of these equations is achieved by an independent calculation using a computer spreadsheet. Results agree to within two significant figures. The spreadsheet and GXQ input file and calculated effective release heights for this case follow.

Table 2H2F. Case 2H2F Check (ISC2 Plume Rise w/ $q_h = 5.0E+6$ w)

Table 2H2F. Case 2H2F, ISC2 Plume Rise

Tamb =	293	K	dstack =	5	m
T0 =	330.234127	K	W0 =	125	m ³ /s
delta T =	37.234127	K	W0 =	6.36619783	m/s
Cp0 =	1005	J/(kg K)			
rho0 =	1.06893858	kg/m ³			
qh =	5.00E+6	W			
Fb =	43.95	m ⁴ /s ³	43.964835	(4.3-3)	
Fm =	224.742882	m ⁴ /s ²	(4.3-5)		

Plume Rise Calculation

GXQ Users' Guide Equation Numbers -		4.3-10,11	4.3-12,13	4.3-7	4.3-21	4.3-24	4.3-20	4.3-16
class	ueff	x	s	stability param.	distance crossover to final temp. difference	buoyant rise	distance dependent momen. rise	final plume momen. rise
a	12.0	100	0.0	0.0	6.2	521.2	4.6	8.0
b	8.0	1000	0.0	0.0	6.2	521.2	12.9	11.9
c	4.0	10000	0.0	0.0	6.2	521.2	28.7	23.9
d	6.0	100	0.0	0.0	6.2	521.2	10.5	15.9
e	4.0	1000	4.3-6	4.3-17	4.3-18	4.3-7	4.3-22	4.3-16,19
f	1.0	20000	4.95E-4	0.9	372.4	73.1	20.2	20.4
g	1.0	100	1.25E-3	1.5	58.6	85.2	43.0	27.8
			2.42E-3	2.0	42.1	68.4	38.5	24.9
								68.4

Atmospheric Dispersion Calculation

		4.1-4	4.2-1	4.2-2	4.1-1
class	ueff	x	heff	sy	sz
a	12.0	100	10.1	23.4	14.3
b	8.0	1000	45.7	140.9	110.2
c	4.0	10000	91.4	855.7	497.8
d	6.0	100	20.3	9.4	4.6
e	4.0	1000	73.1	53.6	21.3
f	1.0	20000	85.2	553.1	58.7
g	1.0	100	68.4	3.1	1.4

VV Case 2H2F: ISC2 Plume Rise

c mode
2

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F T F F

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
2 0 0 0

c

c PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)	
0	10	1000	5	
initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
0	0	0	0.001	0.001
ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (w)
20	57.23	125	5	5E+6
X/Q scaling factor (?)	Wind Speed Exponent			
1	.78			

c RECEPTOR DEPENDENT DATA (no line limit)

1	12	100	0	0
2	8	1000	0	0
3	4	10000	0	0
4	6	100	0	0
5	4	1000	0	0
6	1	20000	0	0
7	1	100	0	0

----- 2H2F.OUT

effective release height (he)	=	10.1367	m
effective release height (he)	=	45.7078	m
effective release height (he)	=	91.4156	m
effective release height (he)	=	20.2735	m
effective release height (he)	=	73.0643	m
effective release height (he)	=	85.2267	m
effective release height (he)	=	68.3543	m

Case 2H2G: Same as Case 2A but with ISC2 Plume Rise w/ $q_h = 1.0E+7$

Discussion and Conclusion

This case tests the GXQ implementation of the ISC2 code procedure for calculating momentum and buoyancy plume rise. The effective release height for each of the atmospheric stability classes (Pasquill A-G) at various wind speeds and distances are calculated. No wind adjustment and therefore, no iteration is necessary. Plume rise is based on a $q_h = 1.0E+7$ w in order to test the buoyancy rise model based on convective heat input and a high buoyancy flux. Verification of correct solution of these equations is achieved by an independent calculation using a computer spreadsheet. Results agree to within two significant figures. The spreadsheet and GXQ input file and calculated effective release heights for this case follow.

Table 2H2G. Case 2H2G Check (ISC2 Plume Rise w/ $q_h = 1.0E+7$)

Table 2H2G. Case 2H2G, ISC2 Plume Rise

Tamb =	293 K	dstack =	5 m
T0 =	378.309264 K	v0 =	125 m3/s
delta T =	85.3092643 K	w0 =	6.36619783 m/s
Cp0 =	1005 J/(kg K)		
rho0 =	0.93309901 kg/m3		
qh =	1.00E+7 W		
Fb =	87.9 m4/s3	87.92967 (4.3-3)	
Fm =	196.182797 m4/s2	(4.3-5)	

Plume Rise Calculation

GXQ Users' Guide Equation Numbers -												
			4.3-10,11	4.3-12,13	4.3-7	4.3-21	4.3-24	4.3-20	4.3-16			
class	ueff	x	stability param. s	crossover temp. difference	distance to final buoyant rise	buoyant rise	momen. xmax	jet entrain. beta m	distance dependent momen. rise	final plume momen. rise	plume rise	
a	12.0	100	0.0	1.5	713.1	12.8	713.1	2.2	4.4	8.0	12.8	
b	8.0	1000	0.0	1.5	713.1	71.0	713.1	1.6	13.7	11.9	71.0	
c	4.0	10000	0.0	1.5	713.1	142.0	713.1	1.0	30.5	23.9	142.0	
d	6.0	100	0.0	1.5	713.1	25.5	713.1	1.3	10.0	15.9	25.5	
equations:			4.3-6	4.3-17	4.3-18	4.3-7	4.3-23	4.3-24	4.3-22	4.3-16,19		
e	4.0	1000	4.95E-4	1.0	372.4	92.1	282.4	1.0	19.3	19.5	92.1	
f	1.0	20000	1.25E-3	1.7	58.6	107.4	44.5	0.5	41.1	26.6	107.4	
g	1.0	100	2.42E-3	2.3	42.1	86.1	31.9	0.5	36.8	23.8	86.1	

Atmospheric Dispersion Calculation

		4.1-4	4.2-1	4.2-2	4.1-1	
class	ueff	x	heff	sy	sz	x/q
a	12.0	100	12.8	23.4	14.3	5.32E-5
b	8.0	1000	71.0	140.9	110.2	2.08E-6
c	4.0	10000	142.0	855.7	497.8	1.79E-7
d	6.0	100	25.5	9.4	4.6	1.85E-10
e	4.0	1000	92.1	53.6	21.3	6.31E-9
f	1.0	20000	107.4	553.1	58.7	1.84E-6
g	1.0	100	86.1	3.1	1.4	0.00E+0

VV Case 2H2G: ISC2 Plume Rise

c mode
2
c
c LOGICAL CHOICES:
c ifox inorm icdf ichk isite ipop
F F F T F F
c
c X/Q AND WIND SPEED ADJUSTMENT MODELS:
c ipuff idep isrc iwind
0 0 0 0
c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:
c iwake ipm iflow ientr
0 0 0 0
c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:
c (irise igrnd iwash)igrav
2 0 0 0
c

c PARAMETER INPUT:

release height (m)	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)	
0	10	1000	5	
initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
0	0	0	0.001	0.001
ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (W)
20	105.3	125	5	1E+7
X/q scaling factor (?)	Wind Speed Exponent			
1	.78			

c RECEPTOR DEPENDENT DATA (no line limit)

1	12	100	0	0
2	8	1000	0	0
3	4	10000	0	0
4	6	100	0	0
5	4	1000	0	0
6	1	20000	0	0
7	1	100	0	0

----- 2H2G.OUT

effective release height (he)	=	12.7715	m
effective release height (he)	=	70.9707	m
effective release height (he)	=	141.941	m
effective release height (he)	=	25.5430	m
effective release height (he)	=	92.0552	m
effective release height (he)	=	107.379	m
effective release height (he)	=	86.1211	m

Case 2I: Same as Case 2G but with Flow Rate Adjustment

Discussion and Conclusion

This case tests the ability of GXQ to calculate a ground level peak air concentration for each of the atmospheric stability classes (Pasquill A-G) at various wind speeds and distances (similar to Case 2G) with a simple adjustment applied to the atmospheric diffusion coefficients to account for the stack volume flow rate. Verification of correct solution of these equations is achieved by an independent spreadsheet calculation. Results agree to within two significant figures. The spreadsheet calculation and GXQ output file for this case follow.

Table 2I. Case 2I Hand Check (Ground Level Puff Release with Flow Adjustment)

Release Duration =	0.000278	hr	1	s
Stack Diameter =	1.13	m		
Volume Flow Rate =	1	m ³ /s		
sqrt(2*pi) =	2.506628			
(2*pi)^(3/2) =	15.74961			
Fref =	2			
G(z) =	2			

Atmos.	Wind							
Stab.	Speed	x	Sigmax(0)	Sigmay(0)	Sigmaz(0)	Virt.x	Virt.y	Virt.z
Class	(m/s)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
A	12	100	4.8e+00	4.5e-01	5.9e-02	1.7e+01	1.3e+00	2.8e-01
B	8	1000	3.2e+00	4.5e-01	8.8e-02	1.5e+01	1.7e+00	5.4e-01
C	4	10000	1.6e+00	4.5e-01	1.8e-01	9.5e+00	2.3e+00	1.6e+00
D	6	100	2.4e+00	4.5e-01	1.2e-01	2.2e+01	3.5e+00	1.6e+00
E	4	1000	1.6e+00	4.5e-01	1.8e-01	2.0e+01	5.0e+00	3.3e+00
F	1	20000	4.0e-01	4.5e-01	7.1e-01	6.6e+00	7.6e+00	2.4e+01
G	1	100	4.0e-01	4.5e-01	7.1e-01	1.0e+01	1.2e+01	4.5e+01

Atmos.	Wind								Plume	Puff	Minimum
Stab.	Speed	x	x+Virt.x	x+Virt.y	x+Virt.z	Sigmax	Sigmay	Sigmaz	X/Q	X/Q	X/Q
Class	(m/s)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(1/m ³)	(1/m ³)	(1/m ³)
A	12	100	117.2	101.3	100.3	27.0	23.7	14.3	7.82e-05	1.38e-05	1.38e-05
B	8	1000	1015.1	1001.7	1000.5	142.8	141.1	110.3	2.56e-06	5.72e-08	5.72e-08
C	4	10000	10009.5	10002.3	10001.6	856.5	855.9	497.9	1.87e-07	3.48e-10	3.48e-10
D	6	100	121.9	103.5	101.6	11.3	9.7	4.6	1.18e-03	2.51e-04	2.51e-04
E	4	1000	1020.4	1005.0	1003.3	54.5	53.8	21.4	6.91e-05	2.02e-06	2.02e-06
F	1	20000	20006.6	20007.6	20024.1	553.3	553.3	58.7	9.79e-06	7.06e-09	7.06e-09
G	1	100	110.4	111.9	144.7	3.4	3.4	1.9	5.04e-02	5.97e-03	5.97e-03

Current Input File Name: 2i.IN

 GXQ Version 4.0
 December 19, 1994

General Purpose Atmospheric Dispersion Code
 Produced by Radiological & Toxicological Analysis
 Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 1.
 Validation documented in WHC-SD-GN-SWD-3003 Rev. 1.
 Code Custodian is Brit E. Hey, WHC, ext. 376-2921.

Run Date = 02/02/95
 Run Time = 15:37:34.52

INPUT ECHO:

VV Case 2I: Air Concentration with Flow Rate Adjustment

c mode
 2

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
 F F F F F F

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
 1 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
 0 0 1 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
 0 0 0 0

c PARAMETER INPUT:

c release	reference		frequency
c height	anemometer	mixing	to
c (m)	height	height	exceed
	(m)	(m)	(%)
c 0.00000E+00	1.00000E+01	1.00000E+03	5.00000E+00

c initial	initial			gravitational
c plume	plume	release	deposition	settling
c width	height	duration	velocity	velocity
c (m)	(m)	(hr)	(m/s)	(m/s)
c 0.00000E+00	0.00000E+00	2.77780E-04	1.00000E-03	1.00000E-03

c		initial	initial		convective
c	ambient	plume	plume	release	heat release
c	temperature	temperature	flow rate	diameter	rate(1)
c	(C)	(C)	(m3/s)	(m)	(w)
c					
	2.00000E+01	2.00000E+01	1.00000E+00	1.13000E+00	1.75000E+06
c					
c	X/Q				
c	scaling	Wind			
c	factor	Speed			
c	(?)	Exponent			
c					
	1.00000E+00	7.80000E-01			

c RECEPTOR DEPENDENT DATA (no line limit)

MODE:

X/Q calculated by stability class and wind speed.

LOGICAL CHOICES:

MODELS SELECTED:

Flow adjustment model.

Gaussian puff model selected.

WARNING/ERROR MESSAGES:

VV Case 2I: Air Concentration with Flow Rate Adjustment

ATM. STAB. CLASS	WIND SPEED (m/s)	DISTANCE (m)	OFFSET (m)	RECEPTOR HEIGHT (m)	SCALED X/Q (1/m3)
A	12.00	100	0	0	1.38E-05
B	8.00	1000	0	0	5.72E-08
C	4.00	10000	0	0	3.48E-10
D	6.00	100	0	0	2.51E-04
E	4.00	1000	0	0	2.01E-06
F	1.00	20000	0	0	7.06E-09
G	1.00	100	0	0	5.97E-03

Case 2J: Same as Case 2A but with Source Term AdjustmentDiscussion and Conclusion

This case tests the GXQ source term adjustment model by simulating an evaporating liquid pool source. Peak air concentration for each of the atmospheric stability classes (Pasquill A-G) at various wind speeds and distances (similar to Case 2A) are calculated. Verification of correct solution of these equations is achieved by an independent spreadsheet calculation. Results agree to within two significant figures. The spreadsheet calculation and GXQ output file for this case follow.

Table 2J. Case 2J Hand Check (Ground Level Evaporating Pool Model)

c =	2					
a =	0.78					
2*pi =	6.283185					
F(y) =	1					
G(z) =	2					
Atmos. Stability Class	Wind Speed (m/s)	x (m)	Sigmay (m)	Sigmaz (m)	X/Q (s/m3)	Modified X/Q (s/m3)
A	12	100	23.41228	14.29972	7.92e-05	1.10e-03
B	8	1000	140.8609	110.2337	2.56e-06	2.59e-05
C	4	10000	855.7333	497.827	1.87e-07	1.10e-06
D	6	100	9.414834	4.55681	1.24e-03	1.00e-02
E	4	1000	53.5589	21.33693	6.96e-05	4.11e-04
F	1	20000	553.092	58.71554	9.80e-06	1.96e-05
G	1	100	3.078542	1.360375	7.60e-02	1.52e-01

WHC-SD-GN-SWD-30003 Rev 1

Current Input File Name: 2j.IN

GXQ Version 4.0
December 19, 1994

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 1.
Code Custodian is Brit E. Hey, WHC, ext. 376-2921.

Run Date = 02/02/95
Run Time = 15:37:36.33

INPUT ECHO:

VV Case 2J: Source Term Adjustment

c mode
2

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
F F F F F F

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
0 0 2 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
0 0 0 0

c

c PARAMETER INPUT:

c	release	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)
c	0.00000E+00	1.00000E+01	1.00000E+03	5.00000E+00
c	initial	initial		
c	plume	plume	release	deposition
c	width	height	duration	velocity
c	(m)	(m)	(hr)	(m/s)
c	0.00000E+00	0.00000E+00	0.00000E+00	1.00000E-03
c				1.00000E-03
c	ambient	initial	initial	convective
c	temperature	plume	plume	heat release
c	(C)	temperature	flow rate	rate(1)
c		(C)	(m3/s)	(m)
c	2.00000E+01	2.20000E+01	1.00000E+00	1.00000E+00
c				0.00000E+00
c	X/Q			
c	scaling	Wind		
c	factor	Speed		
c	(?)	Exponent		
c	2.00000E+00	7.80000E-01		

c

c RECEPTOR DEPENDENT DATA (no line limit)

MODE:

X/Q calculated by stability class and wind speed.

LOGICAL CHOICES:

MODELS SELECTED:

X/Q adjusted for wind speed dependent source term ($c u^a$).
Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

WARNING #3 - Scaled X/Q units do not reflect the user specified scaling factor.

VV Case 2J: Source Term Adjustment

ATM. STAB. CLASS	WIND SPEED (m/s)	DISTANCE (m)	OFFSET (m)	RECEPTOR HEIGHT (m)	SCALED X/Q
A	12.00	100	0	0	1.10E-03
B	8.00	1000	0	0	2.60E-05
C	4.00	10000	0	0	1.10E-06
D	6.00	100	0	0	1.00E-02
E	4.00	1000	0	0	4.07E-04
F	1.00	20000	0	0	1.96E-05
G	1.00	100	0	0	1.52E-01

Case 3: Plot FileDiscussion and Conclusion

This case tests the ability of GXQ to operate in mode 3. This mode uses the same models as those tested above with a facility to generate a three column data file suitable for contour or surface plots. This case calculates X/Q's for stability class F and 1 m/s wind speed out to 1,000 meters with an offset up to 100 meters in increments of 500 and 50 meters respectively. The output file for this example is very small. An actual plot file would contain many more points to achieve a smooth contour. The only unique feature of this mode is the ability to automatically create a grid of x,y coordinates. The X/Q calculation has already been tested above. This case serves to document the results. The GXQ output file for this case follows.

Current Input File Name: 3.IN

 GXQ Version 4.0
 December 19, 1994

General Purpose Atmospheric Dispersion Code
 Produced by Radiological & Toxicological Analysis
 Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 1.
 Validation documented in WHC-SD-GN-SWD-3003 Rev. 1.
 Code Custodian is Brit E. Hey, WHC, ext. 376-2921.

Run Date = 02/02/95
 Run Time = 15:37:38.09

INPUT ECHO:

VV Case 3: Plot File

c mode
 3

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop
 F F F F F F

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind
 0 0 0 0

c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:

c iwake ipm iflow ientr
 0 0 0 0

c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:

c (irise igrnd iwash)igrav
 0 0 0 0

c

c PARAMETER INPUT:

c	release	reference anemometer height (m)	mixing height (m)	frequency to exceed (%)
c	0.00000E+00	1.00000E+01	1.00000E+03	5.00000E+00

c

c	initial plume width (m)	initial plume height (m)	release duration (hr)	deposition velocity (m/s)	gravitational settling velocity (m/s)
c	0.00000E+00	0.00000E+00	2.77780E-04	1.00000E-03	1.00000E-03

c

c	ambient temperature (C)	initial plume temperature (C)	initial plume flow rate (m3/s)	release diameter (m)	convective heat release rate(1) (W)
c	2.00000E+01	2.00000E+01	1.00000E+00	1.13000E+00	1.75000E+06

c

c	X/Q scaling factor (?)	Wind Speed Exponent
c	1.00000E+00	7.80000E-01

c

c RECEPTOR DEPENDENT DATA (no line limit)

MODE:

Plot file of distance, offset and X/Q created.

LOGICAL CHOICES:

MODELS SELECTED:

Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

VV Case 3: Plot File

stability class F
 wind speed 1.00000
 max distance and intervals 1000.00 2
 max offset and intervals 100.000 2
 minimum X/Q calculated and power 0.000000 1.00000

VV Case 3: Plot File

DISTANCE (m)	OFFSET (m)	SCALED X/Q (1/m3)
0.000E+00	0.000E+00	0.00E+00
0.000E+00	5.000E+01	0.00E+00
0.000E+00	-5.000E+01	0.00E+00
0.000E+00	1.000E+02	0.00E+00
0.000E+00	-1.000E+02	0.00E+00
5.000E+02	0.000E+00	1.96E-03
5.000E+02	5.000E+01	8.02E-05
5.000E+02	-5.000E+01	8.02E-05
5.000E+02	1.000E+02	5.46E-09
5.000E+02	-1.000E+02	5.46E-09
1.000E+03	0.000E+00	6.18E-04
1.000E+03	5.000E+01	2.48E-04
1.000E+03	-5.000E+01	2.48E-04
1.000E+03	1.000E+02	1.59E-05
1.000E+03	-1.000E+02	1.59E-05

APPENDIX C
INDEPENDENT REVIEW CHECKLIST

Peer Review Checklist

Document Reviewed: Hey, B. E., 1994, *GXQ 4.0 Verification and Validation*, WHC-SD-GN-SWD-30003, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Scope of Review: Entire Document

Yes	No	NA	
☒	☐	☐	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☒	☐	☐	Problem completely defined.
☐	☐	☒	Accident scenarios developed in a clear and logical manner.
☒	☐	☐	Necessary assumptions explicitly stated and supported.
☒	☐	☐	Computer codes and data files documented.
☒	☐	☐	Data used in calculations explicitly stated in document.
☒	☐	☐	Data checked for consistency with original source information as applicable.
☒	☐	☐	Mathematical derivations checked including dimensional consistency of results.
☒	☐	☐	Models appropriate and used within range of validity or use outside range of established validity justified.
☒	☐	☐	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
☒	☐	☐	Software input correct and consistent with document reviewed.
☒	☐	☐	Software output consistent with input and with results reported in document reviewed.
☐	☐	☒	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
☐	☐	☒	Safety margins consistent with good engineering practices.
☒	☐	☐	Conclusions consistent with analytical results and applicable limits.
☒	☐	☐	Results and conclusions address all points required in the problem statement.
☐	☐	☒	Format consistent with appropriate NRC Regulatory Guide or other standards
☐	☐	☒	Review calculations, comments, and/or notes are attached.
☒	☐	☐	Document approved.

Paul Rettmann
Reviewer (Printed Name and Signature)

3-28-95

Date

I compared GXQ with ISC2 & could explain differences by the ISC2 model and definition for S.