STP Nuclear Operating Company

South Texas Project Electric Generating Station 4000 Avenue F – Suite A Bay City, Texas 77414

May 29, 2008
ABR-AE-08000039

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville MD 20852-2738

South Texas Project
Units 3 and 4
Docket Nos. 52-012 and 52-013
<u>Requests for Additional Information on STP 3 & 4 COLA</u>

Attached are responses to NRC questions included in Request for Additional Information letter numbers 9, 10 R1, 11, 15, 16, 17, 18, 19, 20, 21, and 24 related to COLA Part 2, Tier 2, Sections 2.1, 2.2, 2.3, and 10.4. This submittal includes responses to the following Question numbers:

02.01.02-1
02.01.02-2
02.01.03-1
02.01.03-2
02.02.03-1
02.02.03-2
02.03.01-1
02.03.01-2
02.03.01-3
02.03.01-4
02.03.01-5
02.03.01-6
02.03.01-7
02.03.02-1
02.03.02-2
02.03.02-3
02.03.03-3
02.03.04-1
02.03.04-2
02.03.05-1
02.03.05-2
10.04.07-2

When a change to the COLA is indicated by a question response, the change will be incorporated into the next routine revision of the COLA following NRC acceptance of the question response.

The response to Question 02.03.02-2 references Seasonal/Annual Cooling Tower Impact (SACTI) input files. This information is provided on the CD included with this letter.

There are no new commitments made in this letter.

If you have any questions, please contact me at (361) 972-4626, or Bill Mookhoek at (361)-972-7274.

D079
NRO

I declare under penalty of perjury that the foregoing is true and correct.

Executed on May 29, 2008

Greg Gibson
Manager, Regulatory Affairs
South Texas Project, Units 3 & 4

gsc

Attachments
1. Question 02.01.02-1
2. Question 02.01.02-2
3. Question 02.01.03-1
4. Question 02.01.03-2
5. Question 02.02.03-1
6. Question 02.02.03-2
7. Question 02.03.01-1
8. Question 02.03.01-2
9. Question 02.03.01-3
10. Question 02.03.01-4
11. Question 02.03.01-5
12. Question 02.03.01-6
13. Question 02.03.01-7
14. Question 02.03.02-1
15. Question 02.03.02-2
16. Question 02.03.02-3
17. Question 02.03.03-3
18. Question 02.03.04-1
19. Question 02.03.04-2
20. Question 02.03.05-1
21. Question 02.03.05-2
22. Question 10.04.07-2

Enclosure

CD- SACTI input files

cc: w/o attachment except*
(paper copy)

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Question 02.01.02-1

QUESTION:

From the STP 3 and 4 FSAR Figure 2.1S-4, it is estimated that the minimum distance to EAB from Unit 4 is about 3050 ft. This value is also confirmed from the FSAR Table 2.3S-22 (Page 2.3S-96). But on the STP 3 and 4 FSAR Figure 2.1S-3, the minimum distance to EAB from unit 4 is labeled both on figure and in legend as 2125 ft. Please clarify and correct as appropriate.

RESPONSE:

FSAR Figure 2.1S-3 will be modified to reflect the actual distance (3,050 ft) from the centerline of the Unit 4 Reactor Building to the EAB as shown in Attachment 1. The 2,125 ft distance previously identified on the figure and the legend reflected the distance from any potential release point (closest edge of the power block area) to the EAB.

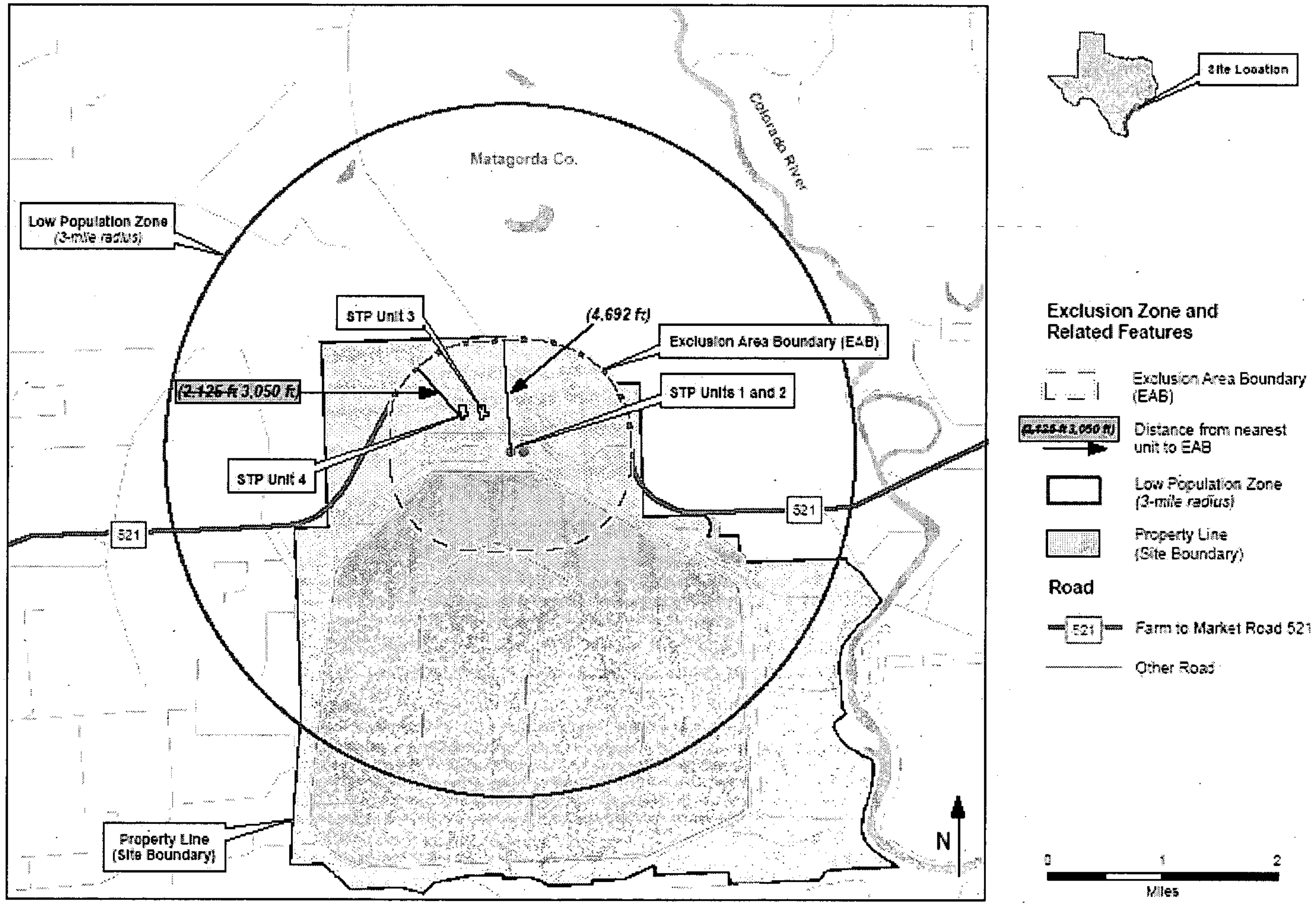


Figure 2.1S-3 Site Area Map

Source Data:

Bechtel, South Texas Project Units 3 & 4, Drawing No. 0-P1-0010-00001 Rev0E.
ESRI, Data & Maps and StreetMap USA, 2005.

Question 02.01.02-2

QUESTION:

Please provide the number of people working at the Visitor Center and Nuclear Training Facility, and the details of their working hours. This information will help in the determination of whether individuals can be evacuated prior to receiving doses that exceed the dose limits.

RESPONSE:

The Visitor Center is located within the Nuclear Training Facility building. The average number of personnel working at the Nuclear Training Facility at any one time during normal working hours is approximately 90. This number includes approximately 40 personnel in the operations requalification program, 45 in various maintenance programs, 3 simulator support personnel, and 2 facility, custodial or other support personnel. The maximum number of personnel that could be working at the Nuclear Training Facility at any one time, based upon facility capacity and scheduling practices is approximately 120.

The initial license training classes are generally conducted during evenings and on weekends. A typical class consists of fewer than 20 students. A support staff of fewer than 5 would generally be expected to be in the Nuclear Training Facility during these training sessions.

The Visitor Center has no permanent staff and is closed to the public except by appointment. It is capable of accommodating up to approximately 60 personnel at any one time.

Therefore, based upon facility capacity and scheduling practices, the maximum number of personnel expected to be at the Visitor Center and Nuclear Training Facility at any one time is conservatively estimated to be approximately 180. Most of these personnel would be permanent plant staff, and thus would not add significantly to the evacuation burden.

No COLA revision is required as a result of this RAI response.

Question 02.01.03-1

QUESTION:

Section 2.1S.3.1 of the FSAR states that an exponential growth rate for each county was calculated based on the state population projections from 2000-2040 (Reference 2.1S-16). Please provide the calculated growth rate for each of the nine counties (Brazoria, Calhoun, Colorado, Fort Bend, Jackson, Lavaca, Matagorda, Victoria, Wharton) that comprise within the 50 miles of the STP site. Is this growth rate used for future 10-year incremental projections from the year 2000 (2010 through 2080) on a linear or exponential basis from year 2000?

RESPONSE:

The calculated growth rate for each of the nine counties (Brazoria, Calhoun, Colorado, Fort Bend, Jackson, Lavaca, Matagorda, Victoria, Wharton) which are fully or partially within 50 miles of the STP site is provided below. The annual growth rates for each county were derived using the projections from the Texas State Data Center.

STP derived an annual growth rate using 2000 county populations and projections for the year 2040 from the Texas State Data Center. The following exponential growth formula was used:

$P_2 = P_1 \text{ x } e^{(r \text{ x } n)}$

STP solved for the annual growth rate (r) using 2040 projections (P_2) and 2000 census data (P_1), and where the variable n represents time in years (i.e. 40). The calculated growth rate for each of the nine counties is provided below. This growth rate was used for future 10-year incremental projections from 2000 (2010 through 2080) on an exponential basis. Multipliers for each decade ($e^{(r \text{ x } n)}$), for each county, were calculated using the annual growth rate (r) using the exponential growth formula. These multipliers are also shown on Attachment 1, along with the populations and formula used to derive them.

No COLA revision is required as a result of this RAI response.

Table

Multipliers

NAME	STATE NAME	STATE FIPS [1]	CNTY FIPS[1]	FIPS[1]	2000	2040	r	2010	2020	2030	2040	2050	2060	2070	2080
Brazoria	Texas	48	039	48039	241767	429766	0.01	1.15	1.33	1.54	1.78	2.05	2.37	2.74	3.16
Calhoun	Texas	48	057	48057	20647	26571	0.01	1.07	1.13	1.21	1.29	1.37	1.46	1.55	1.66
Colorado	Texas	48	089	48089	20390	24782	0.00	1.05	1.10	1.16	1.22	1.28	1.34	1.41	1.48
Fort Bend	Texas	48	157	48157	354452	789864	0.02	1.22	1.49	1.82	2.23	2.72	3.33	4.06	4.97
Jackson	Texas	48	239	48239	14391	17759	0.01	1.05	1.11	1.17	1.23	1.30	1.37	1.44	1.52
Lavaca	Texas	48	285	48285	19210	19316	0.00	1.00	1.00	1.00	1.01	1.01	1.01	1.01	1.01
Matagorda	Texas	48	321	48321	37957	48664	0.01	1.06	1.13	1.20	1.28	1.36	1.45	1.54	1.64
Victoria	Texas	48	469	48469	84088	119276	0.01	1.09	1.19	1.30	1.42	1.55	1.69	1.84	2.01
Wharton	Texas	48	481	48481	41188	50968	0.01	1.05	1.11	1.17	1.24	1.31	1.38	1.45	1.53

SOURCE:
Texas State Data Center. Population Estimates and Projections Program. Office of the State Demographer, Institute for Demographic and Socioeconomic Research, University of Texas at San Antonio. October 2006.

Used 0.5 Scenario

Exponential Growth: $P_2 = P_1 \times e^{(r \times n)}$

Note [1]: **Federal Information Processing Standard (FIPS)**

Question 02.01.03-2

QUESTION:

The NRC siting criteria at 20 miles is 500/sq. mile. The cumulative density should be a factor of the area (sq/mi) of the circle out to 20 miles times the 500 persons/sq mi - that value is about 630,000 (628,000) and not less than 600,000 as displayed in Figure 2.1S-27. Please verify your calculation for the cumulative population for the NRC siting criteria at 20 miles.

RESPONSE:

As shown in Figure 2.1S-16, 50-Mile Region with Direction Sectors, the 20-mile radius for the STP 3 & 4 site extends into the Gulf of Mexico. Calculations performed to determine population projections included an assessment of the actual land area by radius. It was determined that the total land area within 20 miles of the STP 3 & 4 site is 1143.96 sq. mi. (versus $\pi r^2 = 1256.64$ sq. mi.). The total population for the 20-mile radius was then calculated by multiplying 500 persons/sq. mi. by the total land area within the 20-mile radius, since the density will not apply to those areas that are water. Therefore, the population density (500 persons/sq. mi.) multiplied by the land area was determined to be 571,980 people.

No COLA revision is required as a result of this RAI response.

Question 02.02.03-1

QUESTION:

The minimum safe distance values shown in Table 2.2S-9 are said to be based on TNT equivalency method using Regulatory Guide (RG) 1.91 methodology. But they seem much smaller than generally expected. Please explain the methodology in detail.

RESPONSE:

FSAR 2.2S.3-Explosion Methodology:

Regulatory Guide 1.206 requires COL applicants to determine, on the basis of the information provided in the FSAR Sections 2.2.1 and 2.2.2, the potential accidents to be considered as design-basis events and to identify the potential effects of those accidents on the nuclear plant in terms of design parameters (e.g., overpressure) or physical phenomena (e.g., concentration of flammable or toxic cloud outside building structures). Design-basis events internal and external to the nuclear plant are defined as those accidents that have a probability of occurrence on the order of magnitude of 10^{-7} per year or greater; and potential consequences serious enough to affect the safety of the plant to the extent that the guidelines in 10 CFR Part 100 could be exceeded. One of the accident categories considered in selecting design-basis events is explosions. Accidents involving detonations of high explosives, munitions, chemicals, or liquid and gaseous fuels for facilities and activities in the vicinity of the plant or on-site, where such materials are processed, stored, used, or transported in quantity are considered.

An explosion is defined as a sudden and violent release of high-pressure gases into the environment. The release must be sufficiently fast so that energy contained in the high-pressure gas dissipates in a shock wave. (Reference 2.2SA-6) The strength of the wave is measured in terms of overpressures (maximum pressure in the wave in excess of normal atmospheric pressure). Explosions come in the form of detonations or deflagrations. A detonation is the propagation of a combustion zone at a velocity that is greater than the speed of sound in the un-reacted medium. A deflagration is the propagation of a combustion zone at a velocity that is less than the speed of sound in the un-reacted medium. (Reference 2.2SA-4) For an explosion to occur, the following elements must exist simultaneously:

- a flammable mixture (components are thoroughly mixed and are present at a concentration that falls within a flammable composition boundary) consisting of a fuel and oxygen, usually air, or other oxidant
- a means of ignition
- an enclosure or confinement (Reference 2.2SA-6)

Whether an explosion is possible depends in large measure on the physical state of a chemical. In the case of liquids, flammable and combustible liquids often appear to ignite as liquids. However, it is actually the vapors above the liquid source that ignite. (Reference 2.2SA-5, 5.1.2.1.1) For flammable liquids at atmospheric pressure, an explosion will occur only if the non-oxidized, energized fluid is in the gas or vapor form at correct concentrations in air. Physical explosions may also occur with super-heated liquids that flash-evaporate upon the sudden release of the liquid. (Reference 2.2SA-6) The concentrations of formed vapors or gases have an upper and lower bound known as the upper flammable limit (UFL) and the lower flammable limit (LFL). Below the LFL, the percentage volume of fuel is too low to sustain propagation. Above the UFL, the percentage volume of oxygen is too low to sustain propagation. (Reference 2.2SA-5, 5.1.2.2.4)

Two explosion scenarios are evaluated for each flammable chemical capable of sustaining an explosion. The first scenario involves the rupture of a vessel whereby the entire contents of the vessel are released and an immediate deflagration/detonation ensues. That is, upon immediate release, the contents of the vessel are assumed to be capable of supporting an explosion upon detonation (i.e., flammable liquids are present in the gas/vapor phase between the UFL and LFL). The second scenario involves the release of the entire contents of the vessel whereby the gas (or vapors formed from a liquid spill) travel toward the nearest safety-related system, structure, or component and mix sufficiently with oxygen for the vapor cloud to reach concentrations between the UFL and LFL creating the conditions necessary for a vapor cloud explosion whereby detonation occurs. The methodology presented below is representative of the first scenario. (A separate methodology using the Areal Locations of Hazardous Atmospheres (ALOHA) model is used for the second scenario.) Figure 1 summarizes the decision making process/methodologies employed for the two scenarios.

In formulating the methodology for the first scenario, RG 1.91, NUREG-1805, National Fire Protection Association Code, and pertinent research papers were analyzed. While, RG 1.91 was chosen as the starting point, it has limited applicability—RG 1.91 is applicable to:

- solid explosives;
- hydrocarbons liquefied under pressure; and
- airblasts on highway, rail, and water routes.

And, RG 1.91 specifically excludes:

- cryogenically liquefied hydrocarbons, e.g. LNG;
- fixed facilities; and
- pipelines.

Therefore, when devising an appropriate, yet conservative, methodology for atmospheric liquids and gases, other technical guidance and research must be considered to account for the limited applicability of RG 1.91. Presented below is a methodology that is based upon the TNT equivalence and standard safe distance concepts presented in RG 1.91, yet includes the compilation of guidance and research necessary to devise a valid and sensible approach to explosions where RG 1.91 is not applicable.

Methodology for Explosion (TNT Equivalence Calculation):

An explanation of the methodology developed is broken up into three sections based on the phase of the chemical during storage/transportation: atmospheric liquids; liquefied gases; and gases.

I. Atmospheric liquids

For atmospheric liquids, the allowable and actual distances of hazardous chemicals transported or stored were determined in accordance with RG 1.91, Revision 1. Regulatory Guide 1.91 cites 1 psi (6.9 kPa) as a conservative value of positive incident over pressure below which no significant damage would be expected. Regulatory Guide 1.91 defines this safe distance by the Hopkinson Scaling Law Relationship:

$$R \geq kW^{1/3}$$

Where R is the distance in feet from an exploding charge of W pounds of equivalent TNT and k is the scaled ground distance constant at a given overpressure (for 1 psi, the value of the constant k is 45 feet/lbs^3). (Reference 2.2SA-7)

> Because RG 1.91 is *"limited to solid explosives and hydrocarbons liquefied under pressure"* (Reference 2.2SA-7), the guidance provided in determining W, the mass of the substance that will produce the same blast effect as a unit mass of TNT, is specific to solids. RG 1.91 states *"for solid substances more efficient in producing blast effects than TNT, equivalents are known by the manufacturers. For solid substances not intended for use as explosives but subject to accidental detonation, it is conservative to use a TNT equivalence of one in establishing safe standoff distances, i.e., use the cargo mass in Equation (1)"*—the Hopkinson Scaling Law Relationship.

The full adaptation of this guidance-- where the entire mass of the solid substance is potentially immediately available for detonation-- is not applicable to atmospheric liquids. In the case of atmospheric liquids, where only that portion in the vapor phase between the UFL and LFL is available to sustain an explosion, the guidance for determining the TNT equivalent, W, in RG 1.91 is not appropriate. That is, when determining the equivalent mass of TNT available for detonation, the mass of a chemical in the vapor phase cannot occupy the same volume under atmospheric conditions as the same mass of the chemical in its liquid phase. Further, upon release of the full contents of a vessel filled with liquid, vaporization of the total mass of the liquid release would not occur instantaneously in the case of liquids stored at atmospheric pressure or below their boiling points. During this phase change, dispersion and mixing would occur—the ALOHA dispersion model is used to model this phenomenon (Scenario 2). Therefore, the methodology employed considers the maximum gas or vapor within the storage as explosive. Thus, for atmospheric liquid storage, this maximum gas or vapor would involve the container to be completely empty of liquid and filled only with air and fuel vapor at UFL conditions per NUREG-1805. (Note, Scenario 2 conservatively assumes that the entire contents of the vessel are spilled in a 1cm thick puddle under very stable atmospheric conditions to maximize volatilization—a vapor cloud explosion is then modeled using the ALOHA model)

Therefore, for atmospheric liquids, the TNT mass equivalent, W, was determined following guidance in NUREG-1805, where

$$W= (M_{vapor}*\Delta H_c*Y_f)/2000$$

Where M_{vapor} is the flammable vapor mass (lbs), ΔH_c is the heat of combustion (Btu/lb), and Y_f is the explosion yield factor.

Example of Atmospheric Liquid and Vapor Mass Calculation—Gasoline
Chemical Properties of Automotive Gasoline (Reference 2.2SA-1)

Lower Flammability Limit	1.4%
Upper Flammability Limit	7.4%
Vapor Specific Gravity	3.4

To determine the flammable mass:
V_{vap} = Vvessel * UFL

Where:
V_{vap}= flammable vapor volume at UFL, ft^3
Vvessel = liquid (tank) volume, ft^3
UFL= upper flammability limit

$\rho_{vap}=\rho_{air} * SG_{vap}$
Where:
ρ_{air}=air density, lb/ft^3 (0.074 lb/ft^3) (Reference 2.2SA-2)
ρ_{vap}=vapor density, lb/ft^3
SG_{vap}=vapor specific gravity

$M_{vap}=V_{vap} * \rho_{vap}$
Where:
M_{vap}= flammable vapor mass, lbs

And:
Vvessel= 9,000 gal = 9,000 gal * 0.13368 ft^3/gal = 1,203.12 ft^3
V_{vap}= 1,203.12 ft^3 * 7.4%= 89.0309 ft^3

ρ_{vap}= (0.074 lb/ft^3) * 3.4 = 0.2516 lb/ft^3

M_{vap}= 89.03 ft^3 * 0.2516 lb/ft^3 = 22 lbs.

Therefore:
W_{TNT}=(22 * 18,720 * 100%) / 2,000 (Reference 2.2SA-6)

(Note: A 100% yield factor will be attributed to the explosion—this is very conservative because 100% yield cannot be achieved) (Reference 2.2SA-3)

W=205.92 lbs

$R \geq kW^{1/3}$ (Reference 2.2SA-7)

$R \geq 45\ (206)^{1/3}$

$R \geq$ 266 ft

Comparison with RG 1.91 application of TNT equivalence concept to detonations of confined vapor clouds

Note: This methodology is for confined vapor clouds as presented in RG 1.91 and is limited to hydrocarbons liquefied under pressure. In the case of hydrocarbons liquefied under pressure, the assumption is that upon an accidental release of a hydrocarbon liquefied under pressure, the entire contents would immediately undergo extremely turbulent mixing while returning to its gas phase under atmospheric conditions. (Gasoline is used in this example as a comparison.)

- *"the ratios of heat of combustion of hydrocarbons to that of TNT are typically about 10"* (Reference 2.2SA-7)

  (Note: There is no formula provided in RG 1.91 for W, the equivalent mass of TNT; therefore, this interpretation is applied to the formula presented in NUREG-1805)

  $W=M_{vapor}* (\Delta H_c/\Delta H_{c(TNT)}) *Y_f$ (Reference 2.2SA-6)

  $\Delta H_c/\Delta H_{c(TNT)}=10$

  $W= M_{vapor}*(10)*Y_f$

- *"Most assessments... have led to estimates that less than one percent of calorific energy of the substance was released in blast effects"* (Reference 2.2SA-7)

$Y_f=0.01$

$W=M_{vapor}*(10)*(0.01)=M_{vapor}*(0.10)$

"...this corresponds to an equivalence on a mass basis of 10%."

- *"However, there have been accidents in which estimates of the calorific energy released were as high as 10 percent. "* (Reference 2.2SA-7)

  $Y_f=0.10$

  $W = M_{vapor}* (10) * (0.10)= M_{vapor}* (1.0)$

- *"The blast energy realized depends, in great measure, on phenomena that are accident specific... A reasonable upper bound to the blast energy potentially available based on experimental detonations of confined vapor clouds is a mass equivalence of 240 percent."* (Reference 2.2SA-7)

  (Utilizing the formula presented in NUREG-1805, an interpretation leads to the following values for the explosion yield factor, Y_f,--a measure of the portion of the flammable material participating in the explosion)

  $E=M_{vapor}*(240\%) = M_{vapor}*(10) * (Y_f)$ Where, E is the explosive energy released (Reference 2.2SA-6)

  $(10)*Y_f=2.4$
  $Y_f=0.24=24\%$

  - Most Assessments:
    Gasoline used as an example:
    $W=M_{vapor}*10\%= (22 \text{ lbs}) (10\%) =2.2 \text{ lbs.}$
    $R\geq45(2.2 \text{ lbs})^{1/3} = 58.53 \text{ ft}$

  - Worst Accidents:
    $W=M_{vapor}*100\% = (22 \text{ lbs}) (100\%)=22 \text{ lbs.}$
    $R\geq 45 (22 \text{ lbs})^{1/3} = 126.09 \text{ ft}$

  - Enveloping Case:
    $W=M_{vapor}*240\%= (22 \text{ lbs}) (240\%)=52.8 \text{ lbs}$
    $R\geq 45 (52.8)^{1/3} = 168.82 \text{ ft}$

Comparison with RG 1.91 application of TNT equivalence to solids:

As a point of contrast to the methods discussed above, the comparison presented below assumes the full liquid mass of gasoline is a solid with the same blast effect as TNT. Although this assumption is not appropriate for liquids at atmospheric pressure, one must assume this as RG 1.91 specifically states:

> *"This guide is limited to solid explosives and hydrocarbons liquefied under pressure..."*

$R \geq kW^{1/3}$ (Reference 2.2SA-7)

W=50,000 lbs—from *RG 1.91 "for solid substances not intended to be used as explosives but subject to accidental detonation, it is conservative to use a TNT equivalence of one in establishing a safe standoff distance, i.e., use the cargo mass in Equation (1)."* (the Hopkinson Scaling Law Relationship)

$R \geq (45)(50{,}000)^{1/3}$

$R \geq 1{,}658$ feet

(Note that for the solid methodology presented in RG 1.91, the safe-distance determination does not take into account the heats of combustions for a particular substance, therefore, by assuming that a liquid or gas is a solid and proceeding with this method, it would not matter what the flammable chemical was under consideration—for 50,000 pounds of a flammable material, regardless of the material, the safe distance will be 1,658 feet)

II. Liquefied Gases

For liquefied gases, the entire mass is considered as a flammable gas/vapor because a sudden tank rupture would entail the release of a majority of the contents in the vapor/aerosol form and a confined explosion could possibly ensue (i.e., the liquid would violently expand and mix with air while changing states from the liquid phase to a vapor/aerosol phase).

Again, for liquefied gases, the allowable and actual distances of hazardous chemicals transported or stored were determined in accordance with RG 1.91.

In this case the entire mass is conservatively considered available for detonation, the equivalent mass of TNT, W, is calculated as follows:

$W = E/2000$ lb (NUREG-1805, where E is the blast wave energy)
$E = M_{flammable} * \Delta H_c * Y_f$ (NUREG-1805, where Y_f is the explosion yield factor)

Example of Liquefied Gases Calculation--Liquid Propane:

- Quantity: 50,000 lb (RG 1.91-maximum probable hazardous solid cargo for a single highway truck)

- Flammable mass ($M_{flammable}$): 50,000 lb
- Heat of combustion (ΔH_c) (Btu/lb): 19,782 (Reference 2.2SA-1)

E=(50,000 lbs) * (19,782) *(100%) (Reference 2.2SA-6)
E= 9.891E8

W= (9.891E8) / 2000
W=494,550 lbs.

$R \geq 3,559$ ft

Comparison with RG 1.91 application of TNT equivalence concept to possible detonation of confined vapor clouds formed after an accidental release of hydrocarbons:

- Taking the Enveloping Case:
  $W=M_{vapor} * 240\%$
  W= (50,000 lbs) (240%)
  W= 120,000 lbs

  $R \geq (45)\,(120,000)^{1/3}$

  $R \geq 2,219.6$ feet

Comparison with RG 1.91 application of TNT equivalence to solids:

Note: Again, although this assumption is not appropriate for liquefied gases,utilizing this methodology, one would have to assume that the propane is a solid with the same blast effect as TNT.

$R \geq kW^{1/3}$ (Reference 2.2SA-7)

W=50,000 lbs—from RG 1.91 *"for solid substances not intended for use as explosives but subject to accidental detonation, it is conservative to use a TNT equivalence of one in establishing safe standoff distances, i.e., use the cargo mass in Equation (1)."* (the Hopkinson Scaling Law Relationship)

$R \geq (45)\,(50,000)^{1/3}$

$R \geq 1{,}658$ feet

(As noted before, the solid methodology presented in RG 1.91, the safe-distance determination does not take into account the heats of combustions for a particular substance, therefore, by assuming that a liquid or gas is a solid and proceeding with this method, it would not matter what the flammable chemical was under consideration—for 50,000 pounds of a flammable material, regardless of the material, the safe distance will be 1,658 feet)

III. Gases

For pressurized gases, the allowable and actual distances of hazardous chemicals transported or stored were determined in accordance with RG 1.91.

As in the evaluation of liquefied gases, the entire mass is conservatively considered as a flammable gas and available for detonation because a sudden tank rupture would entail the rapid release of a majority of the contents in the vapor/gas phase and a confined explosion could possibly ensue. Therefore, the M_{TNT}, is calculated as follows:

$W=E/2000$ lb (NUREG-1805, where E is the blast wave energy)
$E= M_{flammable} * \Delta H_c * Y_f$ (NUREG-1805, where Y_f is the explosion yield factor)

Example of Pressurized Gas—Hydrogen:

- Quantity: 100,200 ft^3
- Vapor Specific Gravity: 0.067 (Reference 2.2SA-1)
- Heat of Combustion: 50,080 Btu/lb (Reference 2.2SA-1)

$\rho_{vap}=\rho_{air} * SG_{vap}$
Where:
ρ_{air}=air density, lb/ft^3 (0.074 lb/ft^3) (Reference 2.2SA-2)
ρ_{vap}=vapor density, lb/ft^3
SG_{vap}=vapor specific gravity

$M_{vap}=V_{vap} * \rho_{vap}$
Where:
M_{vap}= flammable vapor mass, lbs

$\rho_{vap}= (0.074 \text{ lb/ft}^3) * 0.067= 0.004958 \text{ lb/ft}^3$

$M_{vap}= 100{,}200 \text{ ft}^3 * 0.005 \text{ lb/ft}^3= 503.51 \text{ lb}$

$W= (503.51\text{lb} * 50{,}080 \text{ Btu/lb}) / (2{,}000 \text{ Btu/lb}) = 12{,}607.77 \text{ lbs}$

$R\geq 45 * (12{,}607.77)^{1/3} = 1{,}047.35 \text{ ft}$

Explosions/Vapor Cloud Explosions

Two explosion hazard scenarios are evaluated for each chemical depending on the chemical's physical properties:

- The first scenario involves the rupture of a vessel whereby the entire contents of the vessel are released and an immediate deflagration/detonation ensues.
- The second scenario involves the release of the entire contents of the vessel whereby the gas (or vapors formed from a liquid spill) travel towards the control room and mix sufficiently with oxygen for the vapor cloud to reach concentrations between the LFL and UFL creating the conditions necessary for a VCE whereby detonation occurs.

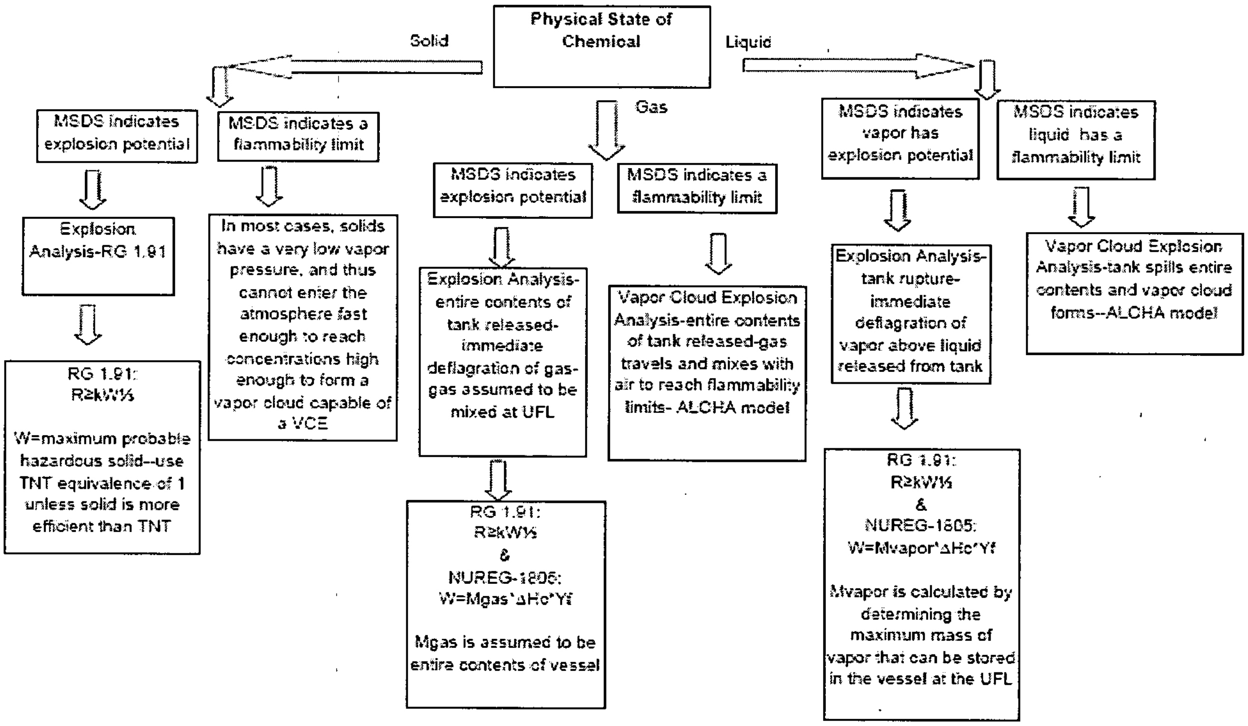


FIGURE 1

Response References

2.2SA-1 Chemical Hazards Response Information System (CHRIS), United States Coast Guard, November 1998.

2.2SA-2 "Flow of Fluids through Valves, Fittings and Pipes." Crane Valves North America. 1988.

2.2SA-3 Factory Mutual Global Property Loss Prevention Data Sheets, Data Sheet 7-42, *Guidelines for Evaluating the Effects of Vapor Cloud Explosions Using a TNT Equivalency Method.* Section 3.4, September 2006.

2.2SA-4 NFPA 68, *Guide for Venting of Deflagrations,* 2002 Edition, National Fire Protection Association.

2.2SA-5 NFPA 921, *Guide for Fire and Explosion Investigations,* 2004 Edition, National Fire Protection Association.

2.2SA-6 NUREG-1805, *Fire Dynamics Tools (FDT^s): Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program,* December 2004.

2.2SA-7 Regulatory Guide 1.91, Rev. 1, *Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants,* U.S. Nuclear Regulatory Commission, February 1978.

To provide an explanation of the explosion methodology, the following new appendix to FSAR Section 2.2S will be inserted:

2.2SA Appendix to FSAR 2.2S.3-Explosion Methodology

Regulatory Guide 1.206 requires COL applicants to determine on the basis of the information provided in the FSAR Sections 2.2.1 and 2.2.2 the potential accidents to be considered as design-basis events and to identify the potential effects of those accidents on the nuclear plant in terms of design parameters (e.g., overpressure) or physical phenomena (e.g., concentration of flammable or toxic cloud outside building structures). Design-basis events internal and external to the nuclear plant are defined as those accidents that have a probability of occurrence on the order of magnitude of 10^{-7} per year or greater; and potential consequences serious enough to affect the safety of the plant to the extent that the guidelines in 10 CFR Part 100 could be exceeded. One of the accident categories considered in selecting design-basis events is explosions. Accidents involving detonations of high explosives, munitions, chemicals, or liquid and gaseous fuels for facilities and activities in the vicinity of the plant or on-site, where such materials are processed, stored, used, or transported in quantity are considered.

An explosion is defined as a sudden and violent release of high-pressure gases into the environment. The release must be sufficiently fast so that energy contained in the high-pressure gas dissipates in a shock wave. (Reference 2.2SA-6) The strength of the wave is measured in terms of overpressures (maximum pressure in the wave in excess of normal atmospheric pressure). Explosions come in the form of detonations or deflagrations. A detonation is the propagation of a combustion zone at a velocity that is greater than the speed of sound in the un-reacted medium. A deflagration is the propagation of a combustion zone at a velocity that is less than the speed of sound in the un-reacted medium. (Reference 2.2SA-4) For an explosion to occur, the following elements must exist simultaneously:

- a flammable mixture (components are thoroughly mixed and are present at a concentration that falls within a flammable composition boundary) consisting of a fuel and oxygen, usually air, or other oxidant
- a means of ignition
- an enclosure or confinement (Reference 2.2SA-6)

Whether an explosion is possible depends in large measure on the physical state of a chemical. In the case of liquids, flammable and combustible liquids often appear to ignite as liquids. However, it is actually the vapors above the liquid source that ignite. (Reference 2.2SA-5, 5.1.2.1.1) For flammable liquids at atmospheric pressure, an explosion will occur only if the non-oxidized, energized fluid is in the gas or vapor form at correct concentrations in air. Physical explosions may also occur with super-heated liquids that flash-evaporate upon the sudden release of the liquid. (Reference 2.2SA-6) The concentrations of formed vapors or gases have an upper and lower bound known as the upper flammable limit (UFL) and the lower flammable limit (LFL). Below the LFL, the percentage volume of fuel is too low to sustain propagation. Above the UFL, the percentage volume of oxygen is too low to sustain propagation. (Reference 2.2SA-5, 5.1.2.2.4)

Two explosion scenarios are evaluated for each flammable chemical capable of sustaining an explosion. The first scenario involves the rupture of a vessel whereby the entire contents of the vessel are released and an immediate deflagration/detonation ensues. That is, upon immediate release, the contents of the vessel are assumed to be capable of supporting an explosion upon detonation (i.e., flammable liquids are present in the gas/vapor phase between the UFL and LFL). The second scenario involves the release of the entire contents of the vessel whereby the gas (or vapors formed from a liquid spill) travel toward the nearest safety-related system, structure, or component and mix sufficiently with oxygen for the vapor cloud to reach concentrations between the UFL and LFL creating the conditions necessary for a vapor cloud explosion whereby detonation occurs. The methodology presented below is representative of the first scenario. (A separate methodology using the Areal Locations of Hazardous Atmospheres (ALOHA) model is used for the second scenario.).

2.2SA.1 Methodology for Explosion (TNT Equivalence Calculation-Scenario 1)

An explanation of the methodology developed is broken up into three sections based on the phase of the chemical during storage/transportation: atmospheric liquids; liquefied gases; and gases.

2.2SA.1.1 Atmospheric liquids

For atmospheric liquids, the allowable and actual distances of hazardous chemicals transported or stored were determined in accordance with RG 1.91, Revision 1. (Reference 2.2SA-7) Regulatory Guide 1.91 cites 1 psi (6.9 kPa) as a conservative value of positive incident over pressure below which no significant damage would be expected. Regulatory Guide 1.91 defines this safe distance by the Hopkinson Scaling Law Relationship:

$$R \geq kW^{1/3}$$

Where R is the distance in feet from an exploding charge of W pounds of equivalent TNT and k is the scaled ground distance constant at a given overpressure (for 1 psi, the value of the constant k is 45 feet/lbs^3). (Reference 2.2SA-7)

In the case of atmospheric liquids, where only that portion in the vapor phase between the UFL and LFL is available to sustain an explosion, the guidance for determining the TNT equivalent, W, in RG 1.91 is not appropriate. That is, when determining the equivalent mass of TNT available for detonation, the mass of a chemical in the vapor phase cannot occupy the same volume under atmospheric conditions as the same mass of the chemical in its liquid phase. Further, upon release of the full contents of a vessel filled with liquid, vaporization of the total mass of the liquid release would not occur filled with liquid, vaporization of the total mass of the liquid release would not occur instantaneously in the case of liquids stored at atmospheric pressure or below their boiling points. During this phase change, dispersion and mixing would occur—the ALOHA dispersion model is used to model this phenomenon (Scenario 2). Therefore, the methodology employed considers the maximum gas or vapor within the storage as explosive. Thus, for atmospheric liquid storage, this maximum gas or vapor would involve the container to be completely empty of liquid and filled only with air and fuel vapor at UFL conditions per NUREG-1805. (Note, Scenario 2 conservatively assumes that the entire contents of the vessel are spilled in a 1cm thick puddle under very stable atmospheric conditions to maximize volatilization—a vapor cloud explosion is then modeled using the ALOHA model)

Therefore, for atmospheric liquids, the TNT mass equivalent, W, was determined following guidance in NUREG-1805, where

$$W= (M_{vapor}*\Delta H_c*Y_f)/2000$$

Where M_{vapor} is the flammable vapor mass (lbs), ΔH_c is the heat of combustion (Btu/lb), and Y_f is the explosion yield factor.

2.2SA.1.1.2 Example of Atmospheric Liquid and Vapor Mass Calculation—Gasoline

Chemical Properties of Automotive Gasoline (Reference 2.2SA-1)

Lower Flammability Limit	1.4%
Upper Flammability Limit	7.4%
Vapor Specific Gravity	3.4

To determine the flammable mass:
V_{vap} = Vvessel * UFL
Where:
V_{vap}= flammable vapor volume at UFL, ft^3
Vvessel = liquid (tank) volume, ft^3
UFL= upper flammability limit

$\rho_{vap}=\rho_{air}* SG_{vap}$
Where:
ρ_{air}=air density, lb/ft^3 (0.074 lb/ft^3) (Reference 2.2SA-2)
ρ_{vap}=vapor density, lb/ft^3
SG_{vap}=vapor specific gravity

$M_{vap}=V_{vap}*\rho_{vap}$
Where:
M_{vap}= flammable vapor mass, lbs

And:

Vvessel= 9,000 gal = 9,000gal * 0.13368 ft^3/gal = 1,203.12 ft^3

V_{vap}= 1,203.12 ft^3 * 7.4%= 89.0309 ft^3

ρ_{vap}= (0.074 lb/ft^3) * 3.4 = 0.2516 lb/ft^3

M_{vap}= 89.03 ft^3 * 0.2516 lb/ft^3 = 22 lbs.

Therefore:

W_{TNT}=(22 * 18,720 * 100%) / 2,000 (Reference 2.2SA-6)

(Note: A 100% yield factor will be attributed to the explosion—this is very conservative because 100% yield cannot be achieved) (Reference 2.2SA-3)

W=205.92 lbs

$R \geq kW^{1/3}$ (Reference 2.2SA-7)

$R \geq 45\ (206)^{1/3}$

$R \geq 266$ ft

2.2SA.1.2 Liquefied Gases

For liquefied gases, the entire mass is considered as a flammable gas/vapor because a sudden tank rupture would entail the release of a majority of the contents in the vapor/aerosol form and a confined explosion could possibly ensue (i.e., the liquid would violently expand and mix with air while changing states from the liquid phase to a vapor/aerosol phase).

Again, for liquefied gases, the allowable and actual distances of hazardous chemicals transported or stored were determined in accordance with NRC Regulatory Guide 1.91.

In this case the entire mass is conservatively considered available for detonation, the equivalent mass of TNT, W, is calculated as follows:

W=E/2000 lb (NUREG-1805, where E is the blast wave energy)

E= $M_{flammable}$ * ΔH_c* Y_f (NUREG-1805, where Y_f is the explosion yield factor).

2.2SA.1.2.1 Example of Liquefied Gases Calculation--Ethylene:

- Quantity: 470,000 lb
- Flammable mass ($M_{flammable}$): 470,000 lb
- Heat of combustion (ΔH_c) (Btu/lb): 20,290 (Reference 2.2SA-1)

E=(470,000 lbs) * (20,290) *(100%) (Reference 2.2SA-6)
E= 9.54E9

W= (9.54E9) / 2000
W=4.76815E6 lbs.

$R \geq 7{,}574.1$ ft

2.2SA.1.3 Gases

For pressurized gases, the allowable and actual distances of hazardous chemicals transported or stored were determined in accordance with RG 1.91.

As in the evaluation of liquefied gases, the entire mass is conservatively considered as a flammable gas and available for detonation because a sudden tank rupture would entail the rapid release of a majority of the contents in the vapor/gas phase and a confined explosion could possibly ensue. Therefore, the M_{TNT}, is calculated as follows:

W=E/2000 (NUREG-1805, where E is the blast wave energy)
$E = M_{flammable} * \Delta H_c * Y_f$ (NUREG-1805, where Y_f is the explosion yield factor)

2.2SA.1.3.1 Example of Pressurized Gas—Hydrogen:

- Quantity: 100,200 ft^3
- Vapor Specific Gravity: 0.067 (Reference 2.2SA-1)
- Heat of Combustion: 50,080 Btu/lb (Reference 2.2SA-1)

$\rho_{vap} = \rho_{air} * SG_{vap}$
Where:
ρ_{air}=air density, lb/ft^3 (0.074 lb/ft^3) (Reference 2.2SA-2)
ρ_{vap}=vapor density, lb/ft^3
SG_{vap}=vapor specific gravity

$M_{vap} = V_{vap} * \rho_{vap}$
Where:
M_{vap}= flammable vapor mass, lbs

ρ_{vap}= (0.074 lb/ft^3) * 0.067= 0.004958 lb/ft^3

M_{vap}= 100,200 ft^3 * 0.005 lb/ft^3= 503.51 lb

W= (503.51lb * 50,080 Btu/lb) / (2,000 Btu/lb) = 12,607.77 lbs

R≥ 45 * (12,607.77)$^{1/3}$ = 1,047.35 ft

2.2SA.2 References

2.2SA-1 Chemical Hazards Response Information System (CHRIS), United States Coast Guard, November 1998.

2.2SA-2 "Flow of Fluids through Valves, Fittings and Pipes." Crane Valves North America. 1988.

2.2SA-3 Factory Mutual Global Property Loss Prevention Data Sheets, Data Sheet 7-42, *Guidelines for Evaluating the Effects of Vapor Cloud Explosions Using a TNT Equivalency Method.* Section 3.4, September 2006.

2.2SA-4 NFPA 68, *Guide for Venting of Deflagrations,* 2002 Edition, National Fire Protection Association.

2.2SA-5 NFPA 921, *Guide for Fire and Explosion Investigations,* 2004 Edition, National Fire Protection Association.

2.2SA-6 NUREG-1805, *Fire Dynamics Tools (FDT^s): Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program,* December 2004.

2.2SA-7 Regulatory Guide 1.91, Rev. 1, *Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants,* U.S. Nuclear Regulatory Commission, February 1978.

Question 02.02.03-2

QUESTION:

Provide sample inputs, and any assumptions made for ALOHA and DEGADIS models used in determining minimum safe distance required for an explosion to have less than one (1) psi peak incident pressure impact due to flammable vapor cloud.

RESPONSE:

Assumptions/Inputs for ALOHA:

Menu	Parameter	Input	Basis
Site Data	Location	Galveston Texas	This is the geographically closest station to the STP nuclear facility in the ALOHA database—ALOHA uses the latitude, longitude, elevation, and time zone of the location of a chemical release in some of its computations—sun angle or solar radiation (latitude, longitude and time of day of calculation) and atmospheric pressure (determined by the location's elevation) (Reference 3)
Site Data	Date and Time	12:00 pm on July 1, 2006	ALOHA calculates the amount of energy coming into the puddle from the atmosphere and from the ground—if the sun is high in the sky (around noon), the amount of energy coming into the puddle is greater than it would be in the early morning or late afternoon, when the sun is lower. The more energy coming in, the higher the evaporation rate. The position of the sun for the date and time is used in determining the solar radiation. (Reference 3)
Setup/Atmospheric	Wind Speed	1 m/s	Murphy, K.G. and K.M. Campe, "Nuclear Power Plant Control Room Ventilation System Design for Meeting General Criterion 19"—typically wind speeds of about 1 m/s represents the worst 5%. (Reference 15) Note, this is conservative if compared to the parameter selection requirements for the US EPA's Risk Management Program "40 CFR 68.22 Offsite consequence analysis parameters. (b)...For the worst case release analysis, the owner or operator shall use a wind speed of 1.5 meters per second... (Reference 1) Additionally, the minimum surface wind speed at 10 m for Pasquill

			Stability Class F is 2 m/s. (Reference 23) Lower wind speeds will prevent the chemical vapor cloud from dispersing prior to reaching the control room.
Setup/Atmospheric	Wind Direction	W	The wind direction determines which way a pollutant cloud will drift. (Reference 3) Note, that in the ALOHA modeling runs conducted, the threat at point function was chosen which allows the user to set the receptor location directly downwind from the source for a worst-case determination. Because the "threat at point" function is utilized, the wind direction selection becomes inconsequential.
Setup/Atmospheric	Wind Measurement Height	10 meters	ALOHA calculates a wind profile based on where the meteorological data is taken. ALOHA assumes that the MET station is at 10 meters. The National Weather Service usually reports wind speeds from a height of 10 meters. (Reference 3) Wind rose data for this project was also taken at a height of 10 meters. And the surface wind speeds for determining the Pasquill Stability Class are defined at 10m. (Reference 23)
Setup/Atmospheric	Ground Roughness	"Open Country"	The degree of atmospheric turbulence influences how quickly a pollutant cloud moving downwind will mix with the air around it and be diluted. Friction between the ground and air passing over it is one cause of atmospheric turbulence. Because the air nearest the ground is slowed the most, eddies can develop. The rougher the ground surface, the greater the ground roughness (Z_0), and the greater the turbulence that develops. A chemical cloud generally travels farther across open country and open water than over an urban area or a forest. This is because it encounters fewer, smaller roughness elements to create turbulence. (Reference 3) This is also the conservative approach when compared to the parameter selection requirements for the US EPA's Risk Management Program "40 CFR 68.22 Offsite consequence analysis parameters. (e) Surface roughness. The owner or operator shall use either urban or rural topography as appropriate." (Reference 1) Selecting "open country" indicates that the terrain is generally flat and there are no obstructions to hinder the travel/dispersion of the vapor cloud—therefore more conservative distances are modeled.
Setup/Atmospheric	Cloud Cover	50%	ALOHA default value—ALOHA uses this value to estimate the amount of incoming

			solar radiation at the time of a chemical release. (Reference 3) Taking into consideration the time of day selected, date and temperature, the determined solar radiation value generated will be conservative especially when taken into account that F stability does not provide for a solar radiation value (F stability is defined as night-time with a cloud cover fraction of ≤ 3/8 and a wind speed of 2-3 m/s) (Reference 23)
Setup/Atmospheric	Air Temperature	25°C	Air temperature influences ALOHA's estimate of the evaporation rate from a puddle surface (the higher the air temperature, the more the puddle is warmed by the air above it, the higher the liquid's vapor pressure is, and the faster the substance evaporates). (Reference 3) Given, the selection of F stability, which occurs at night time with a cloud cover fraction of ≤ 3/8 (Reference 23), 25°C is a conservative selection.
Setup/Atmospheric	Stability Class	F	The atmosphere may be more or less turbulent, depending on the amount of incoming solar radiation as well as other factors. Meteorologists have defined atmospheric stability classes, each representing a different degree of turbulence in the atmosphere. When moderate to strong incoming radiation heats air near the ground, causing it to rise and generate large eddies, the atmosphere is considered unstable (relatively turbulent). When solar radiation is weak or absent, air near the surface has a reduced tendency to rise, and less turbulence develops (stable atmospheres). Stability class has a large effect on ALOHA's prediction of the threat zone size for dispersion scenarios. Under unstable conditions, a dispersing gas mixes rapidly with the air around it and ALOHA predicts that the cloud will not extend as far downwind as it would under more stable conditions, because the pollutant is soon diluted. (Reference 3) F stability represents the worst 5% of meteorological conditions observed at majority of nuclear plant sites (Reference 19). This is also the most stable meteorological class allowed by ALOHA. One must over-ride the meteorological stability class to choose "F" because generally an F stability class only occurs at nighttime with a cloud fraction of ≤ 3/8 and a wind speed of between 2-3 m/s.

			(Reference 23) The selection of a stable stability class such as "F" prevents the cloud from dispersing as it travels towards the control room. This is an extremely conservative assumption when considering the assumptions taken regarding the time of day was taken to maximize "solar radiation"—and this magnitude of solar radiation is generally not plausible with "F" stability class. Therefore, the assumptions taken lend toward maximizing the evaporation rate to obtain a large vapor cloud while choosing a stable meteorological class to prevent the cloud from dispersing and therefore traveling greater distances.
Setup/Atmospheric	Inversion Height	None	An inversion is an atmospheric condition that serves to trap the gas below the inversion height thereby not allowing it to disperse normally. Inversion height has no effect on the heavy gas model.
Setup/Atmospheric	Humidity	50%	ALOHA uses the relative humidity values to estimate the atmospheric transmissivity value; estimate the rate of evaporation from a puddle; and make heavy gas dispersion computations. Atmospheric transmissivity is a measure of how much thermal radiation from a fire is absorbed and scattered by the water vapor and other atmospheric components. (Reference 3)
For Liquid Releases:			
Setup/Source	Puddle	Puddle (For Liquid Releases) *(Note: Direct source is chosen for pollutant gases—see next section of table)*	In ALOHA, the source is the vessel or pool from which a hazardous chemical is released. ALOHA can model four types of sources: (1) direct-chemical releases directly into the atmosphere; (2) puddle-chemical has formed a liquid pool; (3) tank-chemical is escaping from a tank; and (4) gas pipeline-chemical escaping from a ruptured gas pipeline. (Reference 3) For liquids, assuming a puddle release is a conservative option especially when one considers that by choosing the puddle option, the total quantity of the vessel is assumed to be instantaneously spilled. Additionally, if one compares this selection to the parameter selection requirements for the US EPA's Risk Management Program "40 CFR 68.25 Worst-case release scenario analysis. (d) (1) For regulated toxic substances that are normally liquids at ambient temperature, the owner or operator shall assume that the quantity in the vessel or pipe…is spilled instantaneously to form a liquid pool." (Reference 2)

Setup/Source	Puddle	Type of Puddle/ Evaporating Puddle	As a flammable puddle evaporates, it forms a vapor cloud above the puddle, in order for ALOHA to predict the overpressure from a vapor cloud explosion, this type of puddle option is chosen. (Reference 3)
Setup/Source	Puddle	Puddle Area and Volume	The puddle area strongly influences the evaporation rate. The larger the area of a puddle, the higher its evaporation rate. (Reference 3) The area of the puddle is conservatively estimated by taking the entire contents of the tank and assuming the quantity is spilled unto the ground with no containment or depressions in the ground and forms a 1 cm thick puddle. This is also indicative of the worst-case Risk Management Program (RMP) requirements when compared to the parameter selection requirements for the US EPA's Risk Management Program "40 CFR 68.25 (d) Worst-case release scenario—toxic liquids (1) For regulated toxic substances that are normally liquids at ambient temperature, the owner or operator shall assume that the quantity in the vessel ... is spilled instantaneously to form a liquid pool. (i) the surface area of the pool shall be determined by assuming that the liquid spreads to 1 centimeter deep unless passive mitigation systems are in place..."(Reference 2)
Setup/Source	Puddle/Ground Type	Soil	This is the ALOHA default setting. Ground type influences the amount of heat energy transferred from the ground to an evaporating puddle. (ALOHA assumes that the ground does not absorb any of the spilled chemical, and that none of the chemical spilled onto water dissolves into the water.) ALOHA assumes the heat to be transferred most readily from default ground or concrete surfaces into a puddle, and least readily from sandy ground. (Reference 3)
Setup/Source	Puddle/Input Ground Temperature	Air Temperature (25°C)	Ground temperature influences the amount of heat transferred between the ground and the puddle. The warmer the ground, the warmer the puddle and the higher the evaporation rate. ALOHA suggests using air temperature if the ground temperature is unknown. (Reference 3)
Setup/Source	Puddle/Initial Puddle Temperature	Air Temperature (25°C)	ALOHA suggests selecting ambient air temperature if the initial puddle temperature is unknown. (Reference 3)
For Releases of Gases:			
Setup/Source	Direct	Direct (This option was	Source option if the amount of pollutant is known and the gas is released directly. To

		chosen for gas releases)	model a direct release of gas into the atmosphere, an estimate of the amount of pollutant directly entering the atmosphere as a gas is used. This would not apply to liquids spilling from a tank and forming a puddle, because the liquid is not directly entering the atmosphere. (Reference 3)
Setup/Source	Direct/Release	Continuous	A continuous direct release is chosen to account for a release over 10 minutes. A 10-minute release was chosen based upon RMP guidance-- "40 CFR 68.25 Worst-case release scenario analysis (e) (1) for regulated flammable substances that are normally gases at ambient temperature...the owner or operator shall assume that the quantity in the vessel or pipe... is released as a gas over 10 minutes." (Reference 2)
Setup/Source	Direct/Amount Entering the Atmosphere	Total amount over 10 minutes	A continuous direct release is chosen to account for a release over 10 minutes. Again, a release of the entire contents over a 10-minute release period was chosen based upon RMP guidance-- "40 CFR 68.25 Worst -case release scenario analysis (e) (1) for regulated flammable substances that are normally gases at ambient temperature...the owner or operator shall assume that the quantity in the vessel or pipe... is released as a gas over 10 minutes." (Reference 2)
Setup/Source	Direct/Source height	0	The source height is the height of the location of a chemical release above the ground. Source height is zero if the chemical is released at ground-level. A ground-level release is more conservative than an elevated release: ALOHA will predict a longer threat zone for a ground-level release. (Reference 3) Additionally, for comparison, RMP guidance suggests using a ground-level release for worst-case-- "40 CFR 68.22 Offsite consequence analysis parameters (d) Height of release. The worst-case release of a regulated toxic substance shall be analyzed assuming a ground-level (0 feet) release. (Reference 1)
Display	Threat Zone	Blast Area of Vapor Cloud Explosion	This option is chosen to determine the safe distance for a vapor cloud explosion scenario.
Display	Threat Zone/Blast Area of Vapor Cloud Explosion/Time of Vapor Cloud Ignition	Unknown	The ignition time represents the length of time that the cloud mixes with the air around it and becomes diluted in concentration. Therefore, the amount of the vapor cloud that is between the Lower and Upper Explosive Limits (LEL and

			UEL) will depend on the ignition time. By choosing the unknown ignition time, ALOHA, runs explosion scenarios for a range of ignition times that encompass all of the possible ignition times for the scenario. ALOHA takes the results from all of the scenarios and combines them on a single threat zone plot. (Reference 3)
Display	Threat Zone/Blast Area of Vapor Cloud Explosion/Type of Ignition	Ignited by detonation	The "ignited by spark or flame" option is chosen if a typical accidental explosion is modeled. The "ignited by detonation" option is chosen if an intentional explosion or a worst-case accidental explosion is to be modeled. (Reference 3) Therefore, "ignited by detonation" was conservatively chosen.
Display	Threat Zone/Blast Area of Vapor Cloud Explosion/Overpressure Level of Concern	Threat zone Red: 8 psi Orange: 3.5 psi Yellow: 1.0 psi	The yellow threat zone plot of 1.0 psi was chosen to determine the safe distance requirement in accordance with RG 1.91. (Reference 20)
Display	Threat at Point	Relative Coordinates	This option is chosen to obtain specific information about the hazard at a point of interest. (Reference 3) By choosing this option, the hazard value expected if the wind were to carry the cloud of escaping gas directly toward the point of interest is determined (STP site).
Display	Threat at Point	Input X, the downwind distance = the straight line distance from where the chemical is stored to the closest safety related structure. Input Y, the crosswind distance = 0 feet	In order to determine the hazard value expected if the wind were to carry the cloud directly toward the STP site, the minimum distance from the stored chemical to the closest safety related structure was entered with no cross wind distance. These results represent the worst-case hazard levels that could develop at that distance downwind of the source. (Reference 3)
Chemical	Chemical Library	A vapor cloud explosion analysis was modeled for each on and off-site chemical with determined flammability limits.	(See chemical inputs below)

Chemical Inputs/Assumptions:

For each on-site flammable chemical, a vapor cloud explosion analysis was performed following the assumptions listed above. The following on-site chemicals were analyzed, by selecting the appropriate chemical in ALOHA's chemical library:

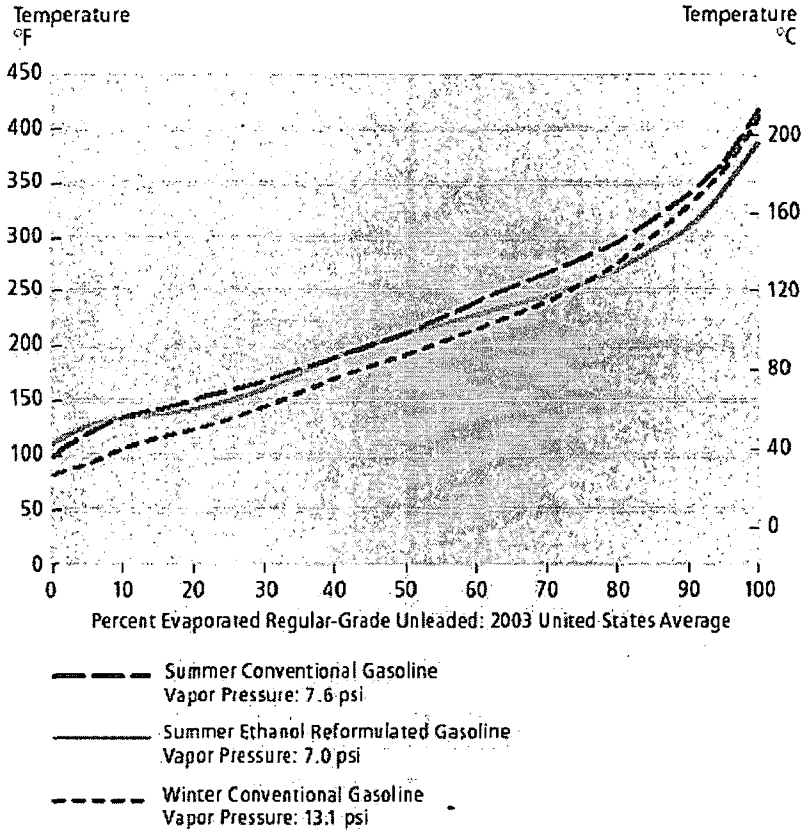
1. Hydrazine
2. Hydrogen (Direct Source)
3. Monoethanolamine
4. Gasoline—n-Heptane was chosen from the chemical library to model gasoline (see note 1)

For each off-site flammable chemical, a vapor cloud explosion analysis was performed following the assumptions listed above. The following off-site chemicals were analyzed by selecting the appropriate chemical in ALOHA's chemical library:

1. 1-Hexene
2. 2-Hexene—it was assumed that 2-Hexene behaves and has similar properties as 1-Hexene and therefore 1-Hexene was chosen from the chemical library (see note 2)
3. 1-Octene
4. Acetaldehyde
5. Acetic Acid
6. Acetone
7. Amerizine Hydrazine
8. Carbon Monoxide (Direct Source)
9. Cyclohexylamine
10. Dimethyl Sulfide
11. Ethyl Acetate
12. Ethylene (Direct Source)
13. Gasoline-- n-Heptane was chosen from the chemical library to model gasoline (see note 1)
14. Hydrogen (Direct Source)
15. Isobutanol
16. Isobutyl Acetate
17. Isobutyraldehyde
18. Methane (Direct Source)
19. n-Butanol
20. n-Butyl Acetate
21. n-Butyraldehyde
22. n-Heptanal
23. n-Propyl Acetate
24. n-Propyl Alcohol
25. Propionaldehyde
26. Propylene (Direct Source)
27. Vinyl Acetate

Note 1: As recommended by the U.S. Environmental Protection Agency (US EPA), gasoline was modeled for vapor cloud explosions by selecting n-Heptane in ALOHA's chemical library. As indicated in an email from Len Wallace of the US EPA, gasoline contains hundreds of hydrocarbons. (Reference 25) Because of this, gasoline boils over a range of temperatures—the boiling point of gasoline is listed as a range, 140-390°F (Reference 6). At the lower end of range of gasoline's boiling point, only a small fraction of the gasoline would be able to evaporate and form a vapor cloud. It was assumed that the entire quantity of gasoline, 12,000 gallons, was modeled as n-Heptane and therefore available to form a vapor cloud. Below is an excerpt from an email from the US EPA, along with a provided distillation graph.

> *"Gasoline is a mixture of hundreds of hydrocarbons, many of which have different boiling points. Thus gasoline boils or distills over a range of temperatures, unlike a pure compound – water, for instance, that boils at a single temperature. A gasoline's distillation profile or distillation curve is the set of increasing temperatures at which it evaporates for a fixed series of increasing volume percentages – 5, 10, 20, 30 percent, etc. – under specific conditions e . (Alternatively, it may be the set of increasing evaporation volume percentages for a fixed series of increasing temperatures.) Figure 1-1 shows the distillation profiles of average conventional summer and winter gasolines. A distillation profile also is shown for a summer reformulated gasoline containing ethanol.*
>
> *Gasoline VP range is 38-300 mmHg (NIOSH)*
>
> *Just three chemicals from Gasloine: Butane 760 mmHg*
>
> *Ethanol 40 mmHg*
>
> *N-Heptane 37 mmHg*
>
> *300 mmHg is the mid range*
>
> *Len Wallace IV*
> *US EPA*
> *1 Congress St Suite 1100 SEP*
> *Boston MA 02114-2023*
> *617 918 1835*
> *Fax 617 918 0835"*



Note 2: The chemical properties of 1-Hexene and 2-Hexene are very similar and therefore, 2-Hexene was assumed to behave similar to 1-Hexene and was modeled as 1-Hexene as chosen from the chemical library in ALOHA (References 12, 22, and 26):

Chemical Property	**1-Hexene**	**2-Hexene**
Molecular Formula	C_6H_{12}	C_6H_{12}
Molecular Weight	84.2	84.16
Boiling Point	63°C	68°C
Flash Point	-26 °C	-5.8°C

Assumptions/Inputs for DEGADIS:

The DEGADIS model was used to compute the flammable mass of gasoline spilled from a barge and its relative location to the original spill site to conduct a vapor cloud explosion analysis. This scenario involves the release of the entire contents of a gasoline barge into the Colorado River whereby the formed pool begins to evaporate, travel and disperse as a vapor cloud. When the vapor cloud is below the upper flammability limit and above the lower flammability limit, a vapor cloud explosion may occur if the vapor cloud is detonated.

Parameter	Input	Basis
Atmospheric Stability Class	F	F stability represents the worst 5% of meteorological conditions observed at majority of nuclear plant sites (Reference 19).
Wind Speed	1.5 m/s	1.5 m/s was chosen using guidance provided in the parameter selection requirements for the US EPA's Risk Management Program "40 CFR 68.22 Offsite consequence analysis parameters. (b)...For the worst case release analysis, the owner or operator shall use a wind speed of 1.5 meters per second... Additionally, the minimum surface wind speed at 10m for Pasquill Stability Class F is 2m/s. (Reference 23) Lower wind speeds will prevent the cloud from dispersing prior to reaching the control room.
Spill Elevation	0 ft	Spill is conservatively assumed to be at the plant elevation. For comparison, RMP guidance suggests using a ground-level release for worst-case-- "40 CFR 68.22 Offsite consequence analysis parameters (d) Height of release. The worst-case release of a regulated toxic substance shall be analyzed assuming a ground-level (0 feet) release. (Reference 1)
Spill Depth	1 cm	A 1 cm thick spill depth was assumed. For comparison, RMP guidance suggests -- "40 CFR 68.25 (d) Worst-case release scenario—toxic liquids (1) For regulated toxic substances that are normally liquids at ambient temperature, the owner or operator shall assume that the quantity in the vessel ... is spilled instantaneously to form a liquid pool. (i) the surface area of the pool

		shall be determined by assuming that the liquid spreads to 1 centimeter deep unless passive mitigation systems are in place…(Reference 2)
Spill area	600,000 ft^2	Spill is initially at its specified maximum area. Given the immense volume of gasoline and the relatively small spill depth, the maximum spill area would require the gasoline to flow miles down the river away from the site. Therefore, the length of the spill area influencing the site is assumed as 1,500 ft (457.2 m) up and down the river from the spill site (the closest point from the river to the proposed site) for a total of 3,000ft (914.4m) in river length. The "Length of the river" or "Length of the spill area" will be defined as the length perpendicular to the shortest distance between the Colorado River and the closest proposed unit. This creates a rectangular spill area with the long side perpendicular to the wind direction. The Colorado River in the vicinity of the Port of Bay City is roughly 200 ft wide (Reference 18). Therefore, the spill area is 600,000 ft^2 (55,741.8 m^2).
Downwind Distance	39,241.8 ft (11, 960.92m)	σ_{yo} = s/4.3 = (3000/4.3)=697.674 ft This correlates to a downwind distance of 7,000 m. Therefore, L= (4,960.92m) + (7,000m)= 11,960.92m (see Note 3 and Figure 1)
Quantity Spilled	1,680,000 gallons	The barge transports in quantities of up to 40,000 BBLs or 1,680,000 gallons (6,359.5m^3). (Reference 11)
Air and Water Temperature	84.1°F = 28.9°C = 302.1 K	To maximize evaporation rate, the July mean temperature is used. (Reference 16) Assuming the water temperature to be the same as the air temperature is conservative as the temperature of the Colorado River is consistently cooler than the air or ground temperature. (Reference 13)
Relative Humidity	50%	

Air Properties	**Air Density:** 1.2 kg/m^3 @ 20°C = 1.29 kg/m^3 @ 0°C = 1.16 kg/m^3 @ 28.9°C **Air Pressure:** 1 atm= 101.325kPa = 14.7 psi **Air Viscosity:** 1.874 E-5 kg/m*s (1.874 E-4 g/cm*s) @ 28.9°C **Molecular Weight of Air:** 28.97 g/mole **Molar Volume of Air:** 20.1 cm^3/mole	(Reference 10) (Reference 14) (Reference 8) (Reference 8)
Water Vapor Pressure	27.7 mmHg (36.93mb) @ 28.9°C	(Reference 17)
Properties of Gasoline	**LFL:** 1.4% **UFL:** 7.4% **Boiling Point (average)**: 333 K to 472 K = 402.5 K **Liquid Heat Capacity:** 0.496 Btu/lb °F @ 80°F & 0.499 Btu/lb °F @ 85 °F = 0.497 Btu/lb °F @ 81.4 °F = 0.497 cal/g °C @28.9 °C = 2,081 J/kg*K @302.1K **Heat of Combustion:** 18,720 Btu/lb **Saturated Liquid Density:**45.24 lb/ft^3 @ 80°F & 45.08 lb/ft^3 @ 85°F = 45.2 lb/ft^3 @ 81.4°F = 6.04 lb/gal @ 81.4°F = 0.724 g/cm^3 @ 28.9 °C **Latent Heat of Vaporization (Average):** 71-81 cal/g = 76 cal/g **Vapor Specific Gravity:** 3.4 **Molecular Weight:** 95 g/mol **Diffusion Coefficient in Air:** 0.008 in^2/s = 0.052 cm^2/s **Reid Vapor Pressure:** 7.49 psia **Saturated Vapor Pressure:** 11.5 in Hg (292 mm Hg) @ 81.4 °F	(Reference 6) (Reference 6) (Reference 6) (Reference 6) (Reference 6) (Reference 6) (Reference 6) (Reference 6) (Reference 5) (Reference 7) (Reference 6) (Reference 4)
Emission rate	95.439 kg/s	(see note 4)
Reference height	10 m	The wind speed must be specified at the given elevation. The elevation is chosen to be representative of the depth of the contaminant layer and is typically taken to be 10m for ground level releases.
Surface roughness length	1.0E-2 m	DEGADIS default value (flat terrain) (Reference 9)
Monin-Obukhov length	11.8m	DEGADIS automatic input based on Pasquill Atmospheric Stability Class. (Reference 9)
Explosion Epicenter	LFL Distance	The 1 psi overpressure distance is measured from the point within the vapor cloud closest to the proposed plant but within the flammability range (LFL distance).

Terrain	Flat	Maintains the integrity of the plume while allowing it to travel as close to the proposed site as possible.
Averaging Time (Deltay)	0 sec	DEGADIS Default Value (Reference 9)
River Velocity	None	Spill area is maintained and not washed downstream farther from the plant. Downwash (cooling) of the gasoline is prevented.
Heat Transfer	None	Not included in the calculation

Note 3:

Virtual Distance:

1. The puddle area that would form from the spilled gasoline would take the form of the river. However, many models such as DEGADIS assume the mass from a single point source. Since the spill area is a long rectangle that is perpendicular to the proposed Units, a point source model would not be accurate. In order to account for the large spill and consequently the resulting large vapor cloud at the spill site, a virtual point source is assumed upwind of the real spill. The virtual point source forms a virtual vapor cloud that would be equivalent to the actual vapor cloud after it travels and reaches the spill site. This equivalent virtual source is assumed using the Gaussian distribution. The virtual distance is the distance between the virtual upwind "point source" and the rectangular spill.

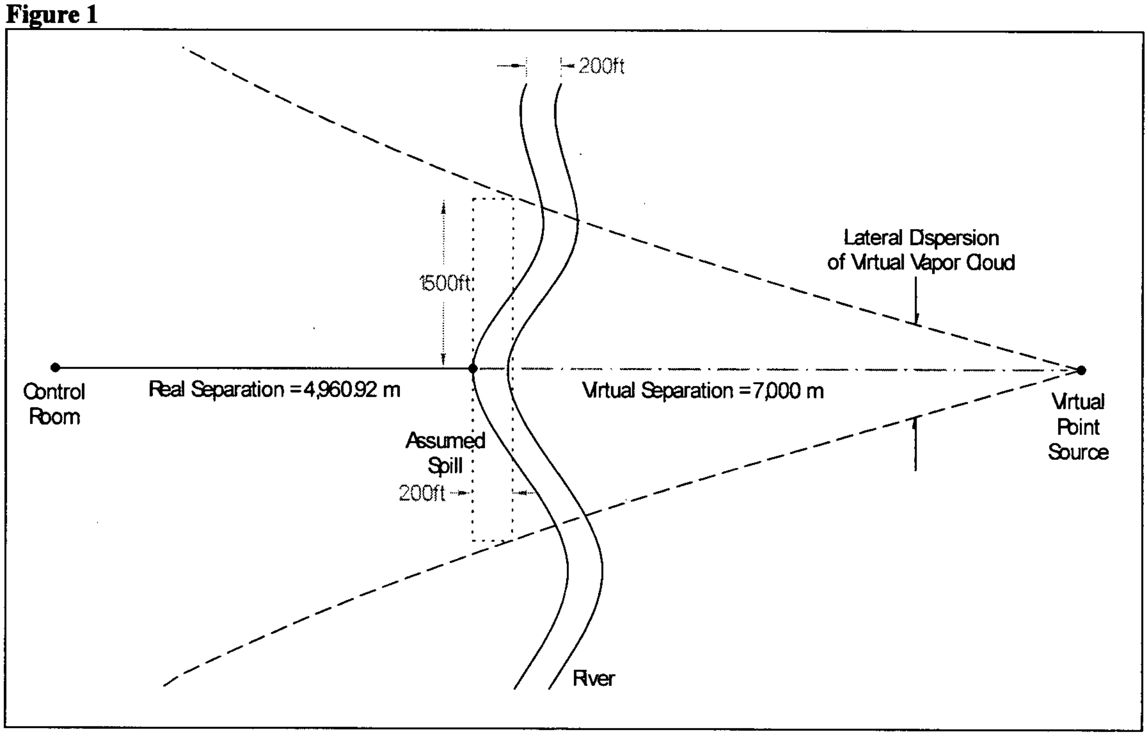
   The initial standard deviation for a 3000 ft square area source is approximated as follows (References 21 and 24):

   $\sigma_{yo} = s/4.3$

   where,
   σ_{yo}= horizontal dispersion parameter (ft)
   s= length of the river side of the rectangular spill area (ft)

   This virtual distance represents the generation of a vapor cloud from a point origin that would be of an equivalent cloud size when it reaches the "real" distance at the river. (See Figure 1 below.)

Figure 1


200ft
1500ft
Lateral Dispersion of Virtual Vapor Cloud
Control Room
Real Separation =4,960.92 m
Virtual Separation =7,000 m
Virtual Point Source
Assumed Spill
200ft
River

Note 4:
Gasoline Emission Estimate (NUREG-0570, Section 2.1.3.2)

Gasoline Emission Estimate Following a Shipment Spill

Total Quantity	1,680,000	gal	(Reference 11)
	6,359,491,824	cm³	
	4,604,272,081	g liquid	
River Spill Length	3,000	ft	Input/Calc'd
River Width	200	ft	(Reference 18)
Spill Depth (t)	1	cm	(Reference 27)
Spill Area (A)	557,418,240	cm²	
Equivalent Spill Radius (r)	13,320	cm	
Ideal Spill Area (Aideal)	6,359,491,824	cm²	
Characteristic length (L, River Width)	6,096	cm	
Wind Speed (u)	150	cm/s	(Reference 1)
Air Temperature (Ta)	302.1	K	(Reference 16)
Atmospheric Pressure (P)	1	atm	
Air Density @ Temperature (Rair)	0.00116	g/cm³	(Reference 10)
Air Viscosity @ Temperature (Nu)	0.0001874	g/cm*s	(Reference 14)
Average Boiling Point (Tb)	402.5	K	(Reference 6)/Avg'd
Vapor Specific Gravity (SGvapor)	3.4		(Reference 6)
Vapor Density @ Temperature (Rv)	0.00394	g/cm³	
Liquid Density @ Temperature (Rliq)	0.724	g/cm³	(Reference 6)/Calc'd
Molecular Weight of Fuel (Mb)	95	g/mole	(Reference 5)
Diffusion Coefficient (Dair)	0.052	cm²/s	(Reference 7)
Sc = Nu/(D*Rair)	3.107		
Re = (L*u*Rair)/Nu	5,660,106.724		
hd = 0.037*(Dair/L)*Re^(0.8)*Sc^(1/3)	0.116	cm/s	(Reference 27)
Saturation Vapor Pressure @ Temp (Ps)	292	mm Hg	(References 4 and 6)
Universal Gas Constant (Rg)	62,363.7	mm Hg*cm³/mole*K	(Reference 10)
Evaporation Rate dm/dt = hd*Mb*A*Ps/(Rg*Ta)	95.439	kg/s	(Reference 27)
Vaporization Time	4,228.557	sec	
	70.476	min	

No COLA revision is required as a result of this RAI response.

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Question 02.03.01-1

QUESTION:

Discuss the influence of the Gulf of Mexico and the resulting land and sea breezes on regional climatology.

RESPONSE:

The Texas coastal sea/land breeze has a large influence on local and regional climatology near the STP site. The inland coastal plains of Texas heat rapidly during summer days causing a large temperature differential between the land and the relatively cooler Gulf of Mexico. The land/sea temperature contrast during the day creates circulation forming a sea breeze, where cooler, more saturated air pushes inland as the warm air rises inland. Also called the "gulf" breeze, it extends about 50 km inland throughout the day. The opposite occurs at night, where inland plains cool rapidly while the sea stays relatively warmer, thus causing a breeze to push off-shore into the Gulf of Mexico.

No COLA revision is required as a result of this RAI response.

Question 02.03.01-2

QUESTION:

Provide statistics on the frequency of occurrence of tornadoes in the STP site region.

RESPONSE:

Tornadoes reported in the contiguous United States from January 1950 through August 2006 were used to determine tornado frequency (NCDC, Storm Events, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms, accessed July 2007).

The STP site is located about N 28° 48' (latitude) and W 96° 3' (longitude). Figure 1 of Regulatory Guide 1.76 uses the 2° boxes to classify tornado intensity regions for the contiguous United States. As a time saving alternative to account for number of tornadoes that occurred nearby the STP site, a circular area was used in order to be equivalent to the approach used by a data retrieval application developed by the National Severe Storms Laboratory (NSSL), called Severe Plot. (http://www.spc.noaa.gov/software/svrplot2). As shown in Figure 1, the circle with a 77.91-mile-radius centered at the STP site covers the same area as the 2° box. To be conservative, all tornadoes were included in this analysis for counties that are either totally or partially covered by the 77.91-mile-radius circle.

Based on the NCDC Storm Events database referenced above, there are 902 tornado occurrences within these counties. After sorting these tornadoes by month, the monthly frequency distribution is presented in Figure 2. For tornadoes that occurred within the nearby counties, on a monthly basis, May and September have the highest frequencies. Among the 902 tornado counts, 153 (17%) occurred in May and 130 (14.4%) occurred in September. On seasonal basis, Fall had the highest count (34.2%) and Spring had the second highest count (31%).

The following paragraphs will be added to the end of FSAR Section 2.3S.1.3.2.

> Tornadoes reported in the contiguous United States from 1950 through 2006 were used to determine tornado frequency (NCDC, Storm Events, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms, accessed July 2007).
>
> The STP site is located about N 28° 48' (latitude) and W 96° 3' (longitude). Figure 1 of Regulatory Guide 1.76 uses the 2° boxes to classify tornado intensity regions for the contiguous United States. As a time saving alternative to account for number of tornadoes that occurred nearby the STP site, a circular area was used in order to be equivalent to the approach used by a data retrieval application developed by the National Severe Storms Laboratory (NSSL), called Severe Plot. (http://www.spc.noaa.gov/software/svrplot2). A circle with a 77.91 mile-radius centered at the STP site covers the same area as the 2° box. To be conservative, all tornadoes

were included in this analysis for counties that are either totally or partially covered by the 77.91 mile-radius circle.

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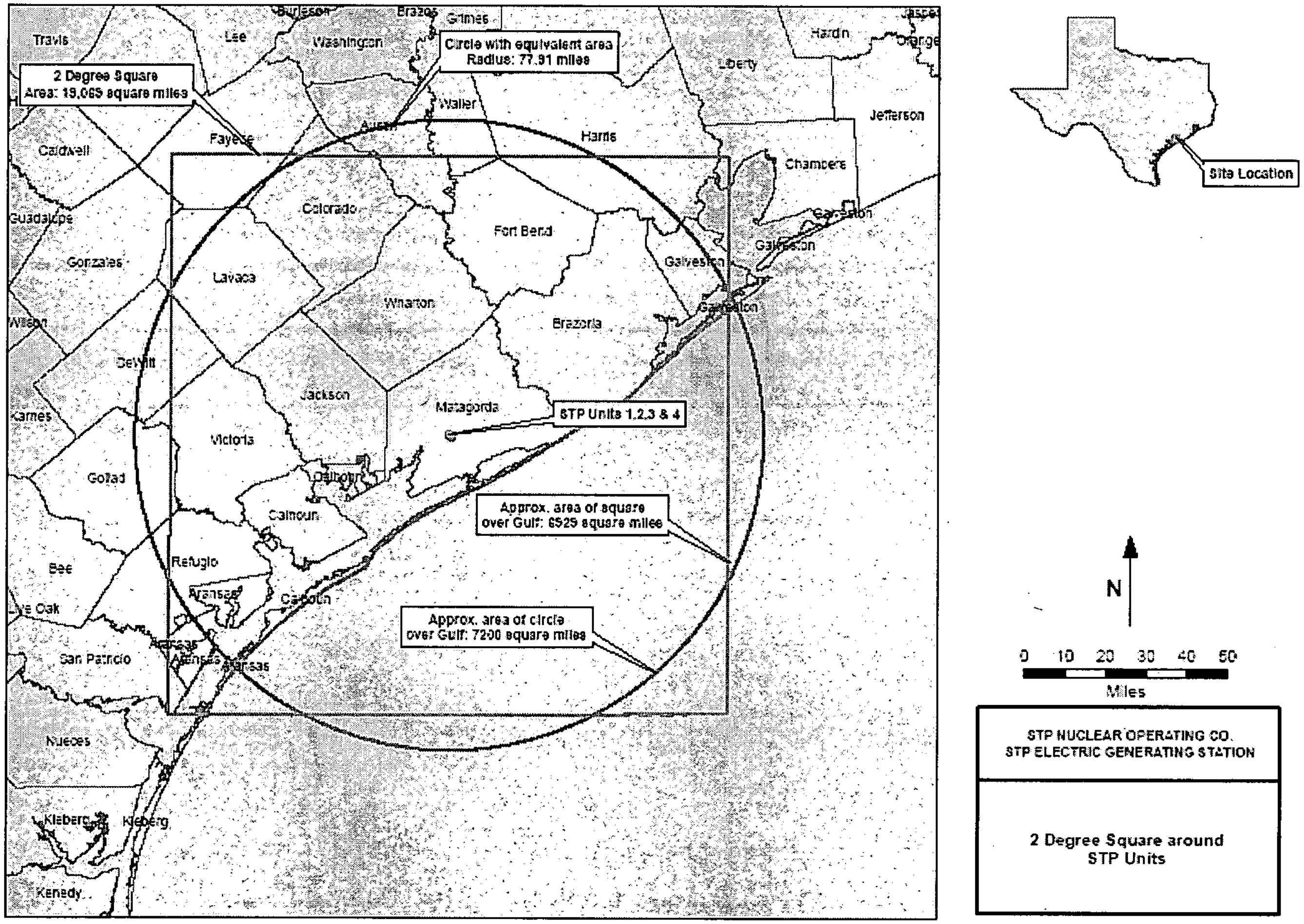
FIGURE 1. Counties Considered Within the 77.91-Mile-Radius Circle



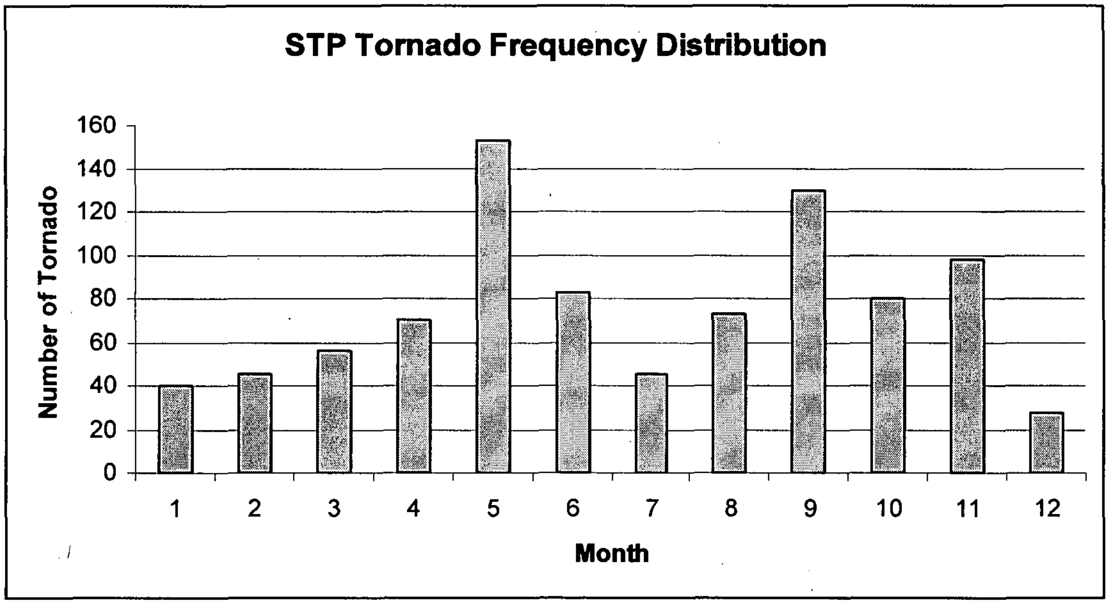
STP NUCLEAR OPERATING CO.
STP ELECTRIC GENERATING STATION

2 Degree Square around
STP Units

Source Data: ESRI, Data & Maps and StreetMap USA, 2005

NAD83 State Plane, Texas South Central FIPS 4204, US Feet

FIGURE 2. Monthly Tornado Frequency Distribution Near the STP Site



Question 02.03.01-3

QUESTION:

The proposed STP site is located within Regulatory Guide (RG) 1.76 tornado intensity Region II but is approximately 22 km from the more conservative tornado intensity Region I. FSAR Section 2.3S.1.3.2 states that the design-basis tornado characteristics taking into consideration information presented in Revision 2 to NUREG/CR-4461. Please explain how information presented in NUREG/CR-4461 was used to select the RG 1.76 Region II design basis tornado characteristics as STP tornado site characteristics.

RESPONSE:

The South Texas Project (STP) site is located about N 28° 48' (latitude) and W 96° 3' (longitude). Based on the 2° boxes provided in Appendix A of NUREG/CR-4461, Revision 2 (also shown in Figure 1 of RG 1.76), the STP site is situated within a 2° box that has a southeast corner located at 27° N and 96° W. The location of this 2° box is classified as a tornado intensity Region II area according to Figure 1 of RG 1.76.

Appendix C to NUREG/CR-4461 presents detailed results of tornado analyses for 1° latitude and longitude boxes. Presented below is summary information for 28° N, 96° W which contains the STP site, and the adjacent 1° boxes. Wind speeds are presented as expected (mean) values (mph). The '---' marks indicates over-water boxes.

Lat-Long	29-97	29-96	29-95
Events	91	139	302
1E-05	128	122	147
1E-06	167	163	184
1E-07	201	198	216

Lat-Long	28-97	28-96	28-95
Events	108	95	19
1E-05	113	121	72
1E-06	156	162	133
1E-07	191	197	173

Lat-Long	27-97	27-96	27-95
Events	130	---	---
1E-05	126	---	---
1E-06	167	---	---
1E-07	201	---	---

The overall classification process used in NUREG/CR-4461 for individual cells, includes a weighting scheme for the adjacent cells (i.e., 28-96, which represents STP, includes data from all adjacent cells that contain data). One of six adjacent cells, 29-95, has an expected wind speed somewhat in excess of the 200 mph definition for Region II. The other two cells are over the

Gulf of Mexico and contain no data. The weighting scheme includes this cell information in the data presented for location 28-96. To see multiple cells where wind potential is significantly greater than the 200 mph definition for Region II, information from 2 cells north, approximately 100 km, would have to be included in the chart.

The NUREG/CR-4461 and RG 1.76 placement of the STP site in tornado intensity Region II is consistent with the data presented in the various Appendices to NUREG/CR-4461, and the tornado intensity classification in FSAR Section 2.3S.1.3.2 is correct for the STP site.

No COLA revision is required as a result of this response.

Question 02.03.01-4

QUESTION:

General Design Criteria (GDC) 2 to Appendix A to 10 CFR Part 50 states that structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as hurricanes without loss of capability to perform their safety functions. GDC 2 further states that the design bases for these structures, systems, and components shall reflect appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

FSAR Section 2.3S.1.3.3 presents information from the NOAA's Coastal Service Center (CSC) historical hurricane track database on the number of tropical cyclone storm tracks that have passed within a 100-nautical mile (nm) radius of the STP site from 1851 through 2006. Using this same database for this same period of record, the staff identified 11 hurricanes that were classified as major (i.e., Saffir/Simpson hurricane category 3 or higher) at the time they made landfall within 100 nm of the STP site. For each of these 11 major hurricanes, the staff used the sustained wind speeds reported in the NOAA CSS database at landfall along with information presented in Table C6-2 of ASCE/SEI 7-05 to estimate the corresponding 3-second gust wind speed over land at landfall. Because hurricane wind speeds typically decrease as storms move inland and the STP site is located approximately 15 mi (24 km) inland from the Gulf of Mexico, the staff reduced the gust wind speed at landfall by 5 mi/h (8 km/h), based on the 5 mi/h reduction in basic wind speed from the coastline to the inland location of the STP site as shown on Figure 6-1A of ASCE/SEI 7-05.

The staff found that a total of 8 out of the 11 major landfall hurricanes had projected gust wind speed values which exceeded the applicant's selected extreme wind basic wind speed site characteristic value of 215 km/h for safety related structures. The strongest of these storms had an estimated inland peak gust wind speed of 298 km/h and the next three strongest storms had estimated inland peak gust wind speeds of 275 km/h. One storm, an unnamed storm occurring on August 27-28, 1945, had a projected storm track directly over the STP site; this storm had an estimated inland peak gust wind speed of 262 km/h.

(a) Please justify why the extreme wind basic wind speed site characteristic value for safety-related structures is not based on the most severe hurricanes that have been historically reported for the site and surrounding area.

(b) Because historic hurricane wind speeds for the STP site and surrounding area have been estimated to exceed the basic wind speed used for the ABWR wind loading design for safety-related structures, please discuss the implications of a wind load in excess of the ABWR design value.

RESPONSE:

(a) As discussed in FSAR Section 2.3S.1.3.1, the site characteristic extreme wind-basic wind speed 50-year recurrence interval value is 125 mph (201 km/h) for a 3 second gust. This value was derived by linear interpolation between wind speed isopleths on the plot of basic wind speeds in Figure 6-1A of ASCE 7-02 for that portion of the US that includes the site for STP 3 & 4. The value obtained for the 50-year recurrence interval was multiplied by a scaling factor of 1.07 to arrive at the 100-year recurrence value of approximately 134 mph (215 km/h). These values (for the 50-year and the 100-year recurrence intervals) are reiterated in FSAR Table 2.0-2, of the STP 3 & 4 COLA, Revision 1. FSAR Table 2.0-2 shows that the site characteristic values for the 50-year and 100-year return periods are bounded by the corresponding ABWR Standard Plant Site Design Parameter values of 126 mph (203 km/h) and 140 mph (226 km/h) respectively.

According to the commentary for ASCE 7, the wind speed map does include consideration of hurricane wind speeds. The map is updated periodically to account for more recent meteorological data and for new and more complete analyses of hurricane wind speeds. A review of the most recent update of ASCE 7 (ASCE 7-05) shows there would be no change to the interpolated value wind speeds for the STP site.

The Acceptance Criteria in Section 2.3.1 of the Standard Review Plan (NUREG 0800) lists climitological information which should be presented and substantiated in accordance with acceptable practice and data as promulgated by the National Oceanic and Atmospheric Administration (NOAA), industry standards and regulatory guides. The parameters listed include the basic (straight-line) 100-year return period 3-second gust wind speed. Furthermore, Section C.I.2.3.1.2, Regional Meteorological Conditions for Design and Operation Bases of Regulatory Guide 1.206 specifies that certain site characteristics, including the 100-year return period 3-second gust wind speed, should be listed for consideration in evaluating the design and operation of the proposed facility. It is for these reasons that the site characteristic extreme wind-basic wind speeds are provided in FSAR Section 2.3S.1.3.1 and FSAR Table 2.0-2. These values are calculated in a manner consistent with the basis for, and are less than, the corresponding ABWR Standard Plant Site Design Parameter values.

The design of safety-related structures to withstand the winds associated with hurricanes is addressed in the response to Part (b) below.

(b) As explained in response to part (a) of the RAI, hurricane winds are considered in the design basis wind. In order to consider the effect of the hurricane winds up to 298 km/hr, the following discussion is provided.

Per Table 5.0 of DCD Tier 1, the following Tornado design parameters were considered for design of Seismic Category I structures covered by DCD design:

Maximum Tornado Wind Speed = 483 km/hr = 300 mph (Note 1)
Maximum Pressure Drop = 13.827 kpa = 2 psi

Note 1: The 300 mph consists of 240 mph rotational and 60 mph translational velocities

The wind velocity pressure "q" in psf can be calculated as being equal to $0.00256V^2$, where V is the wind speed in mph. Thus, the wind pressure is proportional to the square of the wind velocity. Based on this, consider the following:

$V_{Tornado} = 300$ mph
$V_{Hurricane} = 298$ km/hr = 185.2 mph

$R = V_{Tornado} / V_{Hurricane} = 1.62$

$R^2 = 2.62$

Based on the above, for the wind pressure due to hurricane to exceed the pressure due to 300 mph tornado, a load factor of 2.62 will be required to be applied to the hurricane wind pressure. This load factor of 2.62 is in excess of the load factor of 1.7 used for wind in design of concrete Seismic category I structures. Thus, it is concluded that the design of seismic Category I structures for 483 km/hr (300 mph) tornado will envelope the design of these structures for hurricane wind of 298 km/hr (185.2 mph).

There are no changes to the COLA required as a result of this RAI response.

Question 02.03.01-5

QUESTION:

General Design Criteria (GDC) 2 to Appendix A to 10 CFR Part 50 states that structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena without loss of capability to perform their safety functions. GDC 2 further states that the design bases for these structures, systems, and components shall reflect appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated. The maximum snow load site characteristic value should be included in the evaluation of normal live snow loads on the roofs of safety related structures. FSAR Section 2.3S.1.3.4 states that a maximum snow load site characteristic value of 0 kPa (0 lbf/ft2) was chosen for the STP site in accordance with ASCE/SEI 7-02. Please justify why the maximum snow load site characteristic value is not based on the highest snowfall value that has been historically reported for the site and surrounding area.

RESPONSE:

As discussed in FSAR Section 2.3S.1.3.4, based on ASCE/SEI 07-02, the 100-year return period ground-level snow load of 0 kPa (0 psf) would be reasonable for the STP 3 & 4 site. The snow load provisions in ASCE/SEI 07-02 were developed from an extreme-value statistical analysis of weather records of snow on the ground. The weather records were obtained from National Weather Service (NWS) first order and cooperative weather stations.

However, to comply with GDC 2 to Appendix A to 10 CFR Part 50, the maximum snow load site characteristic value will be based on the highest snowfall value that has been historically reported for the site and surrounding area. The maximum occurring snowfall value (10.5 inches) within a 50 mile radius of the STP site occurred at the Danevang 1W station on December 25, 2004.

As discussed in FSAR Section 2.3S.1.3.5, normal snowfall totals at all observing stations in the vicinity of the site average less than 0.5 inches annually. Record snowfalls for these stations occurred on only eight dates over a period of more than 60 years. Given the source of the data (NWS first order and cooperative weather stations), the size of the data sample (from the number of observing stations and the number of years over which the data was collected), and the comparison of the precipitation extremes to the normal annual totals and the published ground level snow loads per ASCE/SEI 07-02, the use of the single maximum snowfall value of 10.5 inches as the basis for the maximum snow load site characteristic is appropriate and sufficient without additional margin to account for limited accuracy, quantity, and period of time in which the historical data have been accumulated.

Using a standard water equivalent ratio from *Hydrology for Engineers* (Reference 1) of 10%, the liquid water equivalent for the 10.5 inch snow, measured at the Danevang 1W station, would be

1.05 inches. Given that one inch of water is 0.249 kPa (5.2 psf), then the weight of the maximum snowfall event is calculated to be 0.263 kPa (5.5 psf).

To reflect use of a maximum snow load site characteristic value, the following changes to FSAR Section 2.3S.1.3.4 will be made:

~~Snow depth measurements were not available for December 25, 2004, or through the end of December although it is noted that the daytime high temperature for December 25 and 26 was above the freezing mark (i.e., in the mid- to upper 30's), and by December 27 had reached 50°F (10°C), increasing to the 70's a few days later. The reported water equivalent for this event was 1.05 in (Reference 2.3S-5). It is reasonable to assume, therefore, that the snow did not remain for more than a few days. Similar characteristics have been observed for other snowfall events in the site area (References 2.3S-4 and 2.3S-5).~~

Estimating the design basis snow load on the roofs of safety-related structures considers both of these climate-related components:

- The weight of the 100-year return period ground-level snowpack (to be included in the combination of normal live loads)
- The weight of the 48-hour probable maximum winter precipitation (PMWP) (to be included, along with the weight of the 100-year return period ground-level snowpack, in the combination of extreme live loads)

From a probabilistic standpoint, the estimated weight of the 100-year return period ground-level snowpack for the STP site area is 0 psf, as determined in accordance with the guidance in Section C7.0 of the ASCE-SEI design standard, "Minimum Design Loads for Buildings and Other Structures" (Reference 2.3S-10).

Considering ~~that~~ the station records for snowfall, summarized in Table 2.3S-3, the maximum occurring snowfall value is 10.5 inches. Using a standard water equivalent ratio of 10%, the liquid water equivalent is 1.05 inches. Based on 0.249 kPa (5.2 psf) per inch of water, the weight of the maximum snowfall event is calculated to be 0.263 kPa (5.5 psf).~~occur on only eight dates over a period of record of more than 60 years and, more importantly, considering the snowfall totals for those events and that they did not appear to persist for any appreciable period of time as ground-level snowpack, determination of the 48-hour PMWP value used for or the evaluation of normal or extreme live snow loads on the roofs of safety-related structures does not appear to be warranted for STP 3 & 4.~~

An update to FSAR Table 2.0-2 will also be made to reflect the revised STP 3 & 4 snow load site characteristic as follows:

Table 2.0-2 Comparison of ABWR Standard Plant Site Design Parameters and STP 3 & 4 Site Characteristics

Subject	ABWR Standard Plant Site Design Parameters	STP 3 & 4 Site Characteristics	Bounded (Yes/No)	Discussion
Precipitation (for Roof Design)	Maximum Snow Load: 2.394 kPa (50 psf)	0 kPa (0 psf) (100-year return snow pack) 0.263 kPa (5.5 psf) (Maximum ground level snow load)	Yes	Further information on maximum snow load is provided in Subsection 2.3S.1.

A typographical error in Table 2.3S-3 relative to the maximum occurring snowfall will also be corrected as follows:

Table 2.3S-3 Climatological Extremes at Selected NWS and Cooperative Observing Stations in the STP 3 & 4 Site Area

Danevang 1W	109 [a, b] (09/06/00) [i]	7 [a] (01/23/40)	12.96 [a] (06/26/60)	24.01 [b, d] (08/45)	10.5 [~~e~~m] (12/~~23~~25/04)	10.5 [~~e~~m] (12/04)

[m] Reference 2.3S-20

Finally, FSAR subsections 3H.6.4.2.4 and 3H.6.4.3.1.3 will be revised as follows:

3H.6.4.2.4 Maximum Snow Load

Design snow load is 0 kPa (100-year return snow pack) and 0.263 kPa (5.5 psf) (Maximum ground level snow load) in accordance with Subsection 2.3S.1.3.4.

3H.6.4.3.1.3 Snow Loads

Design snow load is 0 kPa (100-year return snow pack) and 0.263 kPa (5.5 psf) (Maximum ground level snow load) in accordance with Subsection 2.3S.1.3.4. ~~No~~ A snow load of 0.263 kPa (5.5 psf) is considered in the evaluation of the site-specific seismic Category I structures.

Reference:

1. Linsley, Ray K. *Hydrology for Engineers*, McGraw Hill Inc., United States of America, 1975.

Question 02.03.01-6

QUESTION:

SRP Section 2.3.1 states that the 48-hour probable maximum winter precipitation (PMWP) site characteristic value should be included in the evaluation of extreme live snow loads on the roofs of safety related structures. FSAR Section 2.3S.1.3.4 states that a 48-hour PMWP site characteristic value was not identified because of the infrequent occurrence of snowfall events and the fact that snowfall events do not appear to persist for any appreciable period of time as ground-level snowpack. Nonetheless, the Climatic Atlas of the United States shows that freezing precipitation does occur on average between 2.5 to 5.4 days per year at the STP site and these events do have the potential to clog roof drains. Please identify a 48-hour PMWP site characteristic value for the STP site and describe the additional resulting weight on the roof if all the roof drains are clogged by snow and/or ice.

RESPONSE:

The 48-hour PMWP at the STP site has been calculated through logarithmic interpolation of the worst case 6-hr, 24-hr and 72-hr probable maximum precipitation (PMP) values identified in NUREG/CR-1486. The 48-hour PMWP value is 34 inches of liquid precipitation. To account for the worst case freezing precipitation that could occur in some combination with the worst case 48-hour PMWP, the weight of the maximum snowfall value is determined based on a liquid water equivalent. As calculated in RAI Response 02.03.01-5, the maximum snowfall event (10.5 inches) on December 25, 2004, at the Danevang 1W station is equal to 1.05 inches of liquid precipitation. The weight of the 48-hour PMWP site characteristic value is approximately 177 lbs/ft^2. The weight of the worst case freezing precipitation is approximately 5.5 lbs/ft^2. The appropriate combination of the worst case freezing precipitation and the 48-hour PMWP is a factor in determining the structural loading conditions for roof design.

Per the requirements contained in the ABWR DCD Tier 2 Section 3.4.1.1.1(5), roofs for safety related buildings are designed to prevent pooling of large amounts of water in accordance with Regulatory Guide (RG) 1.102. Appendices 3H.1 and 3H.2 of the ABWR DCD state that roofs are designed with parapets that are furnished with scuppers to supplement roof drains, or are designed without parapets so that excessive ponding of water cannot occur. It goes on to state such roof design meets the provisions of ASCE 7, Section 8.0. Provisions contained in both RG 1.102 and ASCE 7 require the roof to be designed to preclude buildup of standing water (including antecedent or coincident snow or ice) in excess of the structural capacity of the roof. Each portion of the roof shall be designed to sustain the load of all rainwater that will accumulate on it if the primary drainage system for that portion is blocked. Appendix 3H.6 of the COLA FSAR states that the roof structure of the site-specific Seismic Category I structures (e.g., reactor service water pump houses) are designed without parapets so that excessive ponding of water cannot occur.

Based on the design requirements contained in the ABWR DCD, the roof drainage system is adequately designed to function in the event that freezing precipitation may potentially clog the roof drains prior to or during a 48 hour PMWP event.

The last paragraph of FSAR section 2.3S.1.3.4 will be replaced as follows to include the 48-hour liquid PMWP:

> ~~Considering that the station records for snowfall, summarized in Table 2.3S-3, occur on only eight dates over a period of record of more than 60 years and, more importantly, considering the snowfall totals for those events and that they did not appear to persist for any appreciable period of time as ground level snowpack, determination of the 48-hour PMWP value used for or the evaluation of normal or extreme live snow loads on the roofs of safety-related structures does not appear to be warranted for STP 3 & 4.~~
> The 48-hour PMWP value for evaluating extreme live loads is derived from plots of 6-, 24- and 72-hour, 10-square mile area, monthly probable maximum precipitation (PMP) estimates as presented in NUREG/CR-1486 (Reference 2.3S-11). Based on this information, the month of December represents the worst-case (highest) PMP value, in the STP site area, during the winter season in the 6-hour illustration. The months of January and February represent the worst-case PMP values during the winter season in the 24-hour and 72-hour illustrations. The values for the 6-, 24-, and 72-hour PMP values are 17, 28, and 36 inches, respectively. The 48-hour PMWP value, estimated by logarithmic interpolation on the curve defined by the 6-, 24-, and 72-hour PMP values is 34.0 inches liquid depth. The weight of this 34.0 inches of water is approximately 177 lbs/ft^2.
>
> To account for the worst case freezing precipitation that could occur in combination with the worst case 48-hour PMWP, the weight of the maximum snowfall value is converted to a liquid water equivalent. The maximum snowfall event (10.5 inches), mentioned above, is equal to 1.05 inches of liquid precipitation with a corresponding weight of approximately 5.5 lbs / ft^2.

The appropriate combination of freezing precipitation and subsequent liquid precipitation (rainfall) is a factor in determining the structural loading conditions for roof design. The standard ABWR Seismic Category I structures have roofs without parapets, or parapets with scuppers to supplement roof drains so that large inventories of water cannot accumulate. Appendix 3H.6 states that the roof structure of the site-specific Seismic Category I structures (e.g., reactor service water pump houses) are designed without parapets so that excessive ponding of water cannot occur. Therefore, the combination of the worst case freezing precipitation and the 48-hour PMWP will not result in an increase in the roof design loading and therefore will not affect the design of these structures.

Question 02.03.01-7

QUESTION:

FSAR Section 2.3S.1.4 discusses the meteorological data used to evaluate the ultimate heat sink (UHS) performance. Provide the methodology used to screen meteorological data in selecting the minimum water cooling and maximum water usage conditions for use in evaluating the UHS thermal performance.

RESPONSE:

The UHS design described in Revision 1 of the STP 3 & 4 COLA is being modified. The following RAI response applies to the UHS design as currently described in COLA Revision 1. This response will be updated, if necessary, following completion of the UHS design modification, which will be presented in the next revision of the COLA.

The UHS thermal performance, design meteorology, conditions that maximize water temperature, and conditions that maximize water usage are presented in FSAR subsection 9.2.5.5 and Tables 9.2-23a and 9.2-23b. The meteorological data presented in the Tables was developed in accordance with the requirements of Regulatory Guide 1.27, Revision 2 using 45 years of hourly surface weather data from Victoria, Texas. Meteorological data was obtained in SAMSON format from the National Climatic Data Center for the period between 1961 thru 1990, and in TD-3280 format from Trinity Consultants the for period between 1991 thru 2005. These raw data were then converted into CD-144 format using a FORTRAN program. Another FORTRAN program was used to extract and process the CD-144 format data to determine the highest average dry bulb temperature, highest average wet bulb temperature, and highest average evaporation potential for 30 consecutive day and 1 day periods using a running average. The evaporation potential is the difference between the moisture content of saturated air at the dry bulb temperature minus the actual moisture content of the air. The UHS thermal performance analysis was then performed using the 3 sets of processed meteorological data with the highest average wet bulb temperature, highest average dry bulb temperature, and highest average evaporation potential as different cases. The results were then evaluated to determine maximum evaporation (30 day data sets) and maximum basin water temperature (1 day data sets). The meteorological conditions summarized in Tables 9.2-23a and 9.2-23b represent the worst-case for evaporation and temperature, respectively.

The third paragraph in FSAR Section 2.3S.1.4 will be revised as follows:

> ~~Subsection 9.2.5.5 presents the results of the UHS thermal performance. The worst-case meteorological conditions that maximize UHS cooling water temperature (which acts to minimize heat dissipation) over a 1-day (24-hour period) and that maximize water usage over a 30-day period, are addressed in Subsection 9.2.5.5.1. The worse-case meteorological conditions that result in the maximum 30-day cumulative evaporation are addressed in Subsection 9.2.5.5.2. These worst-case meteorological conditions were determined from a 45-year~~

~~period of record of sequential, hourly data from the Victoria, Texas, NWS station. The UHS cooling tower thermal performance analysis was conducted to ensure that UHS system storage and cooling capacities are adequate for 30 days of cooling without makeup or blowdown, and so that the cooling water temperature does not exceed the design limit for design basis heat input and site conditions.~~The UHS thermal performance, design meteorology, conditions that maximize water temperature, and conditions that maximize water usage are presented in FSAR subsection 9.2.5.5 and in Tables 9.2-23a and 9.2-23b. The meteorological data presented in the Tables was developed in accordance with the requirements of Regulatory Guide 1.27, Revision 2 using 45 years of hourly surface weather data from Victoria, Texas. The weather data was analyzed to determine the highest average dry bulb temperature, highest average wet bulb temperature and highest average evaporation potential for 30 consecutive day and 1 day periods using a running average. The evaporation potential is the difference between the moisture content of saturated air at the dry bulb temperature minus the actual moisture content of the air. The UHS thermal performance analysis was then performed using the 3 sets of processed meteorological data with the highest average wet bulb temperature, highest average dry bulb temperature, and highest average evaporation potential as different cases. The results were then evaluated to determine maximum evaporation (30 day data sets) and maximum basin water temperature (1 day data sets). The meteorological conditions summarized in Tables 9.2-23a and 9.2-23b represent the worst-case for evaporation and temperature, respectively.

Question 02.03.02-1

QUESTION:

Please describe the potential impacts of the main cooling reservoir (MCR) and the reactor service water (RSW) system mechanical draft cooling towers on plant design and operation. For example, please address the effects of local increases in ambient temperature, moisture content, and moisture and salt deposition on electrical transmission lines, electrical equipment (including transformers and switchyard), and heating ventilation and air conditioning (HVAC) intakes.

RESPONSE:

The UHS design described in Revision 1 of the STP 3 & 4 COLA is being modified. The following RAI response applies to the UHS design as currently described in COLA Revision 1. This response will be updated, if necessary, following completion of the UHS design modification, which will be presented in the next revision of the COLA.

Reactor Service Water System

The effects of added salt and moisture from the RSW system were determined using the Seasonal/Annual Cooling Tower Impact (SACTI) model. The inputs for this analysis are described in the response to RAI 02.03.02-2.

Salt Deposition:

The Unit 4 transformers are located approximately 550 feet (168 meters) east northeast of the Ultimate Heat Sink (UHS). Maximum salt deposition rates at this location are predicted by SACTI to be between 1056 Kg/ (Km^2-Mo.) (at 100 meters) and 760 Kg/ (Km^2-Mo.) (at 200 meters). This represents light to medium contamination levels over the course of a month according to IEEE Standard C57.19.100-1995 (Reference 1). Since the model assumes the RSW system will be running at full capacity, when in reality it is expected to run closer to half capacity, actual salt deposition rates are expected to be lower. Natural wash off from rain, which SACTI does not consider, is expected to further decrease these values. The Unit 4 transformers are considered bounding for electrical equipment and transmission lines because they are closest to the UHS and SACTI predicts salt deposition to decline rapidly past 200 meters in the direction of the switchyard and electrical equipment.

Moisture:

The SACTI model predicts a maximum of 3.30 hours of fogging annually in any location and 2.83 hours seasonally (winter). Because the HVAC intakes, onsite transmission lines, transformers and switchyard equipment are designed for outdoor operation which includes environmental conditions such as rain and fog, added fog and moisture from cooling tower plumes are not expected to have an adverse effect on these plant features. Furthermore, as discussed in the response to RAI 02.03.02-2, the RSW system will be running at a far lower capacity than the model assumed which will limit plume fogging.

Temperature:

As discussed in Section 9.4 of the ABWR DCD, safety-related HVAC systems are designed for an outdoor summer temperature of 115°F. The temperature of the exhaust plume from the UHS will not exceed the basin water temperature which has a design temperature of 95°F. Therefore, added heat from the UHS will not have adverse effects on the HVAC systems.

Main Cooling Reservoir

The SACTI model is used to analyze cooling towers; therefore, the code was not considered when addressing potential effects from the MCR.

Salt Deposition:

Any salt deposits on the HVAC systems and electrical equipment from the MCR will be a result of evaporation of the cooling water. Since there is no exit velocity from the evaporative process as in a cooling tower, most of the salt content will remain in the pond. Therefore, salt deposits on HVAC intakes, transmission lines and other electrical equipment as a result of evaporation from the MCR is not expected to affect these plant components.

Moisture:

The additional water flow from STP Units 3 & 4 to the MCR will increase ambient moisture as a result of raised pond temperatures and evaporation. Although additional fogging may result from the UHS cooling tower plume, the MCR was designed for four units and the HVAC intakes, transmission lines and onsite electrical equipment are designed for outdoor operation, which include environmental conditions such as fog and rain. Thus, no adverse effects to these plant features are expected. Furthermore, HVAC systems are designed to regulate relative humidity which will further mitigate any potential effects.

Temperature:

As discussed above, safety-related HVAC systems are designed for an outdoor summer temperature of 115°F. The analysis described in COLA Part 3, Environmental Report (ER) Table 3.4-3 shows the maximum predicted monthly MCR temperature at the Circulating Water System (CWS) discharge for 4-unit operation from 2003-2005 is 112.3°F. As discussed in ER Section 3.4.2.4, the design MCR intake temperature for STP 3 & 4 is 100°F. Since both the intake design temperature and maximum monthly overall CWS discharge are lower than the outdoor HVAC design temperature, added heat from the MCR is not expected to adversely affect the HVAC systems. Furthermore, since the design basin temperatures for the UHS are lower than that of the MCR intake temperature values, combined temperature effects from the UHS and the MCR will be similar to those from the MCR.

No COLA revision is required as a result of this RAI response.

References:

1. IEEE Standard C57.19.100-1995, IEEE Guide for Application of Power Apparatus Bushings, Reaffirmed December 9, 2003.

Question 02.03.02-2

QUESTION:

Please describe the assumptions and provide a copy of the input files used to execute the Seasonal/Annual Cooling Tower Impact (SACTI) computer code for estimating the impacts from fogging, icing, and drift deposition from the operation of the reactor service water (RWS) system mechanical draft cooling towers.

RESPONSE:

The UHS design described in Revision 1 of the STP 3 & 4 COLA is being modified. The following RAI response applies to the UHS design as currently described in COLA Revision 1. This response will be updated, if necessary, following completion of the UHS design modification, which will be presented in the next revision of the COLA.

The STP Unit 3 & 4 reactor service water (RSW) system was modeled as two towers with a maximum drift rate of 0.01%. Site-specific meteorological data acquired from the STP 1 & 2 meteorological tower for 1997, 1999 and 2000 was used as input for the code. The site-specific data included the wind speed, wind direction, and dry bulb temperature. Additional meteorological data required for the SACTI analysis was acquired from the National Weather Service for the Palacios Municipal Airport Weather Station, also for the years 1997, 1999, and 2000. This data included the total sky clearness value, the dew point temperature, and the ceiling height. The site dry bulb temperature and the Palacios dew point temperature were used to calculate the wet bulb temperature and the relative humidity.

For the SACTI model, the towers were assumed to be operating during emergency reactor shutdown where the towers are running at full capacity. Under normal operating conditions the RSW system will operate at only half capacity. Sodium concentration of the makeup water is discussed in COLA Part 3 Environmental Report (ER) Section 2.3.1 and it was assumed that all sodium would be associated with chloride for a corresponding NaCl concentration. The SACTI input files are included with this RAI Response on the attached compact disc (CD).

No COLA revision is required as a result of this RAI response.

Question 02.03.02-3

QUESTION:

Discuss the influence of the Gulf of Mexico and the resulting land and sea breezes on local meteorology.

RESPONSE:

The Texas coastal sea/land breeze has a large influence on local and regional climatology near the STP site. The inland coastal plains of Texas heat rapidly during summer days causing a large temperature differential between the land and the relatively cooler Gulf of Mexico. The land/sea temperature contrast during the day creates circulation forming a sea breeze, where cooler, more saturated air pushes inland as the warm air rises inland. Also called the "gulf" breeze, it extends about 50 km inland throughout the day. The opposite occurs at night, where inland plains cool rapidly while the sea stays relatively warmer, thus causing a breeze to push off-shore into the Gulf of Mexico.

Due to the urban heat island effect, the sea breeze is enhanced by large metropolitan areas (i.e., Corpus Christi, Galveston, and Houston). According to *The Houston Heat Pump: Modulation of a Land-Sea Breeze by an Urban Heat Island* (Nielsen-Gammon, 2000) temperatures in urban areas are up to 2°C warmer than in agricultural areas. This would induce a stronger circulation with greater wind speeds and temperatures. Based on 2006 census, the population at Victoria is only about 22% of that at Corpus Christi. As a result, compared to Corpus Christi, the heat island effect over Victoria is expected to be weaker. Therefore, although both Corpus Christi and the STP site both have the gulf breeze influence, the local sea breeze encountered at the STP site area is not as strong as at Corpus Christi.

No COLA revision is required as a result of this RAI response.

Question 02.03.03-3

QUESTION:

FSAR Section 2.3S.3.4.1.2 compares stability class frequency distributions between the original onsite meteorological data set (1973-1977) and the current onsite meteorological data set (1997, 1999, and 2000). Please explain the 6% increase of onsite A stability class frequency from the original data set to the current data set as shown in FSAR Table 2.3S-20 (see Figure 1).

RESPONSE:

Atmospheric stability class distributions during the periods of 1973-1977, as well as the 1997, 1999 and 2000 periods, are presented in FSAR Table 2.3S-19 and summarized in FSAR Table 2.3S-20. Commercial operations of STP Units 1 and 2 commenced in August 1988 and June 1989, respectively. Therefore, both Tables 2.3S-19 and 2.3S-20 represent atmospheric conditions at pre- and post-operation of STP Units 1 and 2.

Heat transfer from the MCR would increase the lower level ambient temperature and create or enhance thermal instability. This MCR-induced effect would result in more unstable atmospheric conditions. The extremely unstable atmospheric condition (Stability Class A) during the pre-operation period was 7.6% (Reference FSAR Table 2.3S-20). The same stability class increases to 13.7% during the post-operation period of the MCR (Reference FSAR Table 2.3S-20). The MCR is located about one mile southwest of the primary meteorological tower. FSAR Table 2.3S-10 indicates that for Stability Class A, the southern sector winds (SE through SW) account for 72% of the total frequency. With this relatively high frequency distribution of the southern winds, the 6% increase of the onsite Stability Class A is mainly attributed to the thermal instability contributed by the MCR.

No COLA revision is required as a result of this RAI response.

Question 02.03.04-1

QUESTION:

Please describe the inputs used to execute the ARCON96 atmospheric dispersion computer code for each source-receptor combination (e.g. direction, distance, intake height, release height, building area, initial diffusion coefficients) to derive the control room and technical support center atmospheric dispersion factors (CHI/Q values) as represented in FSAR Table 2.3S-25.

RESPONSE:

The UHS design described in Revision 1 of the STP 3 & 4 COLA is being modified. The following RAI response applies to the UHS design as currently described in COLA Revision 1. This response will be updated, if necessary, following completion of the UHS design modification, which will be presented in the next revision of the COLA.

The following information provides a description of the inputs used to execute the ARCON96 atmospheric dispersion computer code for each source-receptor combination.

Source 1
Reactor Building Plant Stack

Release Type		Ground
Height of Release Point	[m]	76.00
Vertical Velocity	[m/s]	0.00
Stack Flow	[m^3/s]	158.00
Stack Radius	[m]	0.00
Cross-sectional area*	[m^2]	2133.82

		Receptor 1	**Receptor 2**	**Receptor 3**
		Control Room Air Intake "C"	Control Room Air Intake "B"	Tech Support Center Air Intake
Receptor Air Intake Height	[m]	6	6	10
Direction to Source from Receptor / Window Width	[degrees/ degrees]	225 / 90	180 / 90	250 / 90
Distance from Source to Receptor	[m]	71.6	53.3	103.6

Initial Diffusion Coefficients, meters: 0.0, 0.0. This is representative of a ground level release.

*In calculating the Reactor Building Plant Stack X/Qs, the building cross-sectional area was estimated to be the side of the Reactor Building adjacent to the Control Room Building, which is the smaller side of the Reactor Building. This is a conservative approach because a smaller cross-sectional area will result in higher X/Q values.

Source 2
Turbine Building Truck Doors

Release Type		Ground
Height of Release Point	[m]	3.96
Vertical Velocity	[m/s]	0.00
Stack Flow	[m3/s]	0.00
Stack Radius	[m]	0.00
Cross-sectional area*	[m^2]	3801.64

		Receptor 1	**Receptor 2**	**Receptor 3**
		Control Room Air Intake "C"	Control Room Air Intake "B"	Tech Support Center Air Intake
Receptor Air Intake Height	[m]	6	6	10
Direction to Source from Receptor / Window Width	[degrees/ degrees]	327 / 90	350 / 90	318 / 90
Distance from Source to Receptor	[m]	126.5	109.7	172.2

Initial Diffusion Coefficients, meters: 0.0, 0.0. This is representative of a ground level release.

*In calculating the Turbine Building Truck Door X/Qs, the building cross-sectional area was estimated to be the side of the Turbine Building adjacent to the Control Room Building, which is the smaller side of the Turbine Building. This is a conservative approach because a smaller cross-sectional area will result in higher X/Q values.

Default Values used (both sources):

Surface Roughness Length, meters:	0.2
Wind Direction Window, degrees:	90
Minimum Wind Speed, meters/second:	0.5
Averaging Sector Width Constant:	4.3
Hours in Averages:	1 2 4 8 12 24 96 168 360 720
Minimum Number of Hours:	1 2 4 8 11 22 87 152 324 648
Flag for Expanded Output:	n

No COLA revision is required as a result of this RAI response.

Question 02.03.04-2

QUESTION:

Discuss the influence of the main cooling reservoir on the EAB and LPZ atmospheric dispersion estimates presented in FSAR Section 2.3S.4.

RESPONSE:

The primary meteorological tower is located slightly more than a mile from the Main Cooling Reservoir (MCR). Because of the relatively large size of the MCR (>7000 acres), it is expected that the MCR would have an influence on the observed meteorological data, especially when the meteorological tower is downwind (southern winds) from the MCR.

Dew point measurement is expected to be somewhat higher when the tower is downwind of the MCR. Warmer temperatures from the MCR would tend to increase the lower level temperature and increase or create thermal instability. This effect enhances the dispersion of releases occurring near the plant site. Atmospheric stability class distributions from 1973 to 1977 and in 1997, 1999 and 2000 are presented in Table 2.3S-20 of the FSAR. Commercial operation of STP Units 1 and 2 commenced on August 1988 and June 1989, respectively. Table 2.3S-20 presents atmospheric conditions both pre- and post-operation of Units 1 and 2. The frequency of extremely unstable atmospheric condition (Stability A) recorded during the pre-operational period was 7.6%. This same stability class increased to 13.7% during operation of the MCR. The 6% increase of the A stability class is mainly attributed to the contribution from the MCR.

Table 2.3S-10 indicates that for Stability Class A, the southern winds (SE through SW) account for 72% of the total frequency. Based on the above, the operation of the MCR enhances the dispersion at the EAB and LPZ. However, because the worst case X/Qs at the EAB or LPZ occur under low wind and stable conditions, the increase of the unstable conditions has an insignificant effect on the maximum X/Q estimates at the EAB or LPZ. Thus, the EAB and LPZ atmospheric dispersion estimates presented in FSAR Section 2.3S.4 do not change.

No COLA revision is required as a result of this RAI response.

Question 02.03.05-1

QUESTION:

Discuss the influence of (1) the main cooling reservoir, and (2) the Gulf of Mexico and the resulting land and seabreezes on the routine release atmospheric dispersion estimates presented in FSAR Section 2.3S.5.

RESPONSE:

When local ambient air temperatures are very high, the Main Cooling Reservoir (MCR) will slightly decrease local air temperature. However, under normal conditions, cooling water temperatures will slightly increase local ambient air temperatures and, as a result, the presence of the Main Cooling Reservoir (MCR) will increase local thermal instability. Increased instability will, in turn, enhance local dispersive properties, lowering overall routine release X/Q values. Seabreezes from the Gulf of Mexico will tend to increase routine release X/Q values due to local air recirculation. To account for seabreezes from the Gulf of Mexico, the default recirculation factors in the XOQDOQ code were used when modeling dispersion from routine releases.

To address the influence of the MCR and Gulf of Mexico on routine atmospheric dispersion estimates, a new paragraph will be inserted between paragraphs six and seven of FSAR Section 2.3S.5.1:

> Distances from the STP 1 & 2 reactors to various receptors of interest (i.e., nearest residence, meat animal, EAB boundaries, and vegetable garden) for each directional sector are provided in the STP 1 & 2 Offsite Dose Calculation Manual (Reference 2.3S-54). The shortest distances from the STP 3 & 4 Reactor Buildings to these same receptors of interest are recalculated for each directional sector. The results are presented in Table 2.3S-26.
>
> Because cooling water temperatures will slightly increase local ambient air temperatures, the presence of the MCR will increase local air instability. Increased instability will, in turn, enhance local dispersive properties, lowering overall routine release X/Q values. In addition, sea breezes from the Gulf of Mexico will tend to increase routine release X/Q values due to local air recirculation.
>
> To account for possible effects from Matagorda Bay and the Gulf of Mexico on local meteorological conditions, default correction factors were implemented in the XOQDOQ model. These factors were implemented to satisfy section C2.c of RG 1.111 (Reference 2.3S-45) and properly account for possible recirculation due to land-water boundaries, which could raise X/Q values in an open terrain area such as the STP plant site.

Question 02.03.05-2

QUESTION:

Please explain the purpose for listing in FSAR Table 2.3-27 X/Q and D/Q values at the Unit 4 Reactor location. What assumptions were used to derive these values? What are they used for?

RESPONSE:

X/Q and D/Q values were analyzed at the Unit 4 Reactor location with a primary release point at Unit 3. This scenario was reviewed to evaluate the impact on Unit 4 when Unit 3 is operational and Unit 4 is still under construction. Specifically, the gaseous effluent doses to the Unit 4 construction workers from Unit 3 operation are shown in COLA Part 3, Environmental Report Section 4.5. To clarify why this scenario was addressed in the COLA, an additional item will be added to the listing provided in the fourth paragraph of COLA Tier 2 FSAR Section 2.3S.5.1.

- X/Q and D/Q values at the Unit 4 reactor were estimated based on the assumption that the Unit 3 reactor is operational while the Unit 4 reactor is still under construction.

Question 10.04.07-2

QUESTION:

Regulatory Guide 1.206, Section C.I.10.4.7 states in part that the applicant should describe the condensate and feedwater system (CFS). A description of the CFS is included in Section 10.4.7.2 of the STP FSAR. Departure STP 10.4-5 modifies the CFS by adding components (condensate booster pumps) and changing the system configuration. FSAR Section 10.4.7.2.2, "Component Description," does not include a component description for the condensate booster pumps which was added to the CFS by departure STP 10.4-5. Since the condensate booster pumps are major component of the STP CFS system, please explain why the condensate booster pumps are not included in the component descriptions in Section 10.4.7.2.2 of the FSAR.

RESPONSE:

The condensate booster pumps are considered major components. As a result, the following new paragraph will be added at the beginning of FSAR subsection 10.4.7.2.2 (equating to between "Condensate Pumps"and "Low-Pressure Feedwater Heaters"in the DCD).

Condensate Booster Pumps

Four identical and independent, 33% capacity, fixed speed motor-driven condensate booster pumps are provided between the condensate purification system and the low pressure feedwater heaters. Three pumps normally operate in parallel, with the fourth pump in standby. The condensate booster pumps, in combination with the main condensate pumps, provide the required NPSH for the main feed water pumps and achieve the design pressure for the condensate purification system.