Jim Clary & Associates, Inc.

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Dear Professional:

Enclosed is some information pertaining to the new downwash treatments in the ISC models. Please note that the current releases of both programs still contain "bugs". EPA estimates that the revisions will not be available for several weeks.

We have shipped revised [illegible] models. The current version of the ISCST model is 88207; I [illegible] have ISCST version 88166. This version does contain t[illegible] the 88207 version. (We were aware of the modificat[illegible] version 88207.) Therefore, the only difference betwe[illegible]07 is the version number.

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Please call if you ha[illegible] you have not received your updates. Also, remember th[illegible]tact the reviewing agency to define the modeling protocol.

Yours very truly,

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REVISED DOWNWASH TREATMENT

IN AIR DISPERSION MODELS ISCST & ISCLT

September 19, 1988

PREPARED BY

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1. INTRODUCTION

The Change 3 modifications to the UNAMAP versions of the ISCST and ISCLT models, released in early January, 1988, contain a revised building downwash treatment. This revised downwash treatment includes a refined method based upon the suggestions of Schulman , Scire and Hanna. This new method is referred to as the "Schulman-Scire treatment". Earlier versions of the program used the Huber-Snyder treatment for all downwash cases.

The purpose of this document is to describe the new methods and what impact they will have on calculated concentrations. A "how-to" description is presented. The last section contains a discussion of the results of the current versions of the ISCST and ISCLT. Information about existing program errors is presented.

Comments are welcome at any time. Copies of the input files and output files used in the example runs are also available upon request.

2. DOWNWASH TREATMENTS

The following describes the revised downwash treatment in the ISCST and ISCLT:

$H_s > H_b + 1.5\ L$	No Downwash
$H_s < H_b + 1.5\ L$ and $H_s > H_b + 0.5\ L$	Huber-Snyder
$H_s < H_b + 0.5\ L$	Schulman-Scire

where:
- Hs = stack height
- Hb = building height
- L = the lesser of the building height or width.

Plume rise is not used on the determination of the type of downwash treatment. However, both of the downwash treatments do use the plume rise to determine if downwash should be applied. Therefore, downwash may not be applied even if $H_s < H_b + 1.5\ L$.

The new Schulman-Scire treatment requires direction-dependent building parameters. The ISCST model was modified to read 36 direction-dependent building parameters (every 10 degrees). The ISCLT model was modified to read 16 direction-dependent building parameters (every 22.5 degrees).

The method used by the two programs is as follows:

The normal source line is read. This line includes the direction-independent building parameters.* If the direction-independent building parameters are zero, no downwash calculations are performed. If the regulatory default option is set, or the direction-independent building height is entered as a negative number, and the direction-independent building parameters are not zero, then the program will read the direction-dependent building parameters. However, if:

*correct hb by π/2

$$Hs > Hb + 0.5\ L$$

where:
Hs = stack height
Hb = direction-independent building height
L = the lesser of the direction-independent building height or the direction-independent width (Wb)

Then the direction-independent building parameters do not meet the Schulman-Scire criteria, and the direction-dependent variables are not used. However, they must still be included in the input file. The direction-dependent variables are only used if the direction-independent building parameters meet the Schulman-Scire criteria.

After reading the source data, the program begins to calculate concentrations. If the direction-dependent building parameters are not used for the source, then the model applies the Huber-Snyder treatment using the direction-independent building parameters.

If the ~~building~~ direction-dependent parameters are read and used, then the following procedure is used to determine the type of downwash used for each hour for each source/receptor pair:

$Hs > Hb(d) + 1.5\ L(d)$	No Downwash
$Hs < Hb(d) + 1.5\ L(d)$ and $Hs > Hb(d) + 0.5\ L(d)$	Huber-Snyder using the direction-independent building parameters found on the source line.
$Hs < Hb(d) + 0.5\ L(d)$	Schulman-Scire using the direction-dependent building parameters.

where:

Hs = stack height

Hb(d) = direction-dependent building height for wind direction d

L(d) = the lesser of the direction-dependent building height or the direction-dependent width (Wb(d)) for wind direction d.

Consider the following example. The stack height is 50 meters. The direction-independent building height is 40 meters; the width is 70 meters. The direction-dependent building widths are either zero or greater than the direction-independent building heights. Thus, L(d) is equal to Hb(d). If Hb(d) is less than 20 meters then no downwash will be applied for the direction in question. If Hb(d) is between 20 and 33.3 meters, then the Huber-Snyder treatment will be used with the direction-independent building parameters. If Hb(d) is greater than 33.3 meters, then the Schulman-Scire treatment is used with the direction-dependent parameters.

The following points should be considered about this methodology:

- The direction-dependent building parameters are only used in the Schulman-Scire treatment. The direction-independent building parameters are only used in the Huber-Snyder treatment, even though the direction-independent parameters meet the Schulman-Scire criteria of $Hs < Hb + 0.5 L$. For example if the following parameters are defined:

  Hs = 50 meters
  Hb = 40 meters
  Wb = 70 meters
  Wb(d) = 60 meters

  Then the same concentrations will be determined for Hb(d) = 31 meters and Hb(d) = 21 meters. In both cases, Huber-Snyder will be used with Hb = 40 meters and Wb = 70 meters.

- In certain conditions, a decrease in building height may result in a increase in concentrations. For example, in the above case if Hb(d) = 34 meters, then the Schulman-Scire treatment is applied using a building height of 34 meters. If Hb(d) is decreased to 31 meters, then the Schulman-Scire criteria is not met, and the Huber-Snyder treatment is used. But the Huber-Snyder treatment only used the direction-independent building parameters (Hb = 40 meters). In this case, the concentrations found for the Schulman-Scire treatment with a building height of 34 meters may result in lower concentrations than the Huber-Snyder treatment with a building height of 40 meters.

  - If the direction-dependent building parameters do not meet the Schulman-Scire criteria, then the models apply the same downwash treatment as used in the earlier version (Huber-Snyder using the direction-independent parameters).

  - If the direction-dependent building parameters do not meet the Schulman-Scire criteria, then the direction-dependent parameters are only used to determine if the Huber-Snyder treatment is to be used. The direction-dependent parameters are not used in the downwash treatment. Thus, identical downwash treatments will be used for a wide range of direction-dependent building parameters.

3. DETERMINING BUILDING PARAMETERS

A method is described that may be used in determining the building parameters. Please note that one should not apply the method described in this report before obtaining approval from the agency responsible for reviewing the study. This method does reflect the guidance obtained from EPA.

The first step in any modeling study is to perform a Good Engineering Practice (GEP) stack height analysis. This analysis will determine if building downwash is required. The Good Engineering Practice (GEP) stack height, defined in 40 CFR 51, is defined as follows:

$$GEP = Bh + 1.5 \times L$$

where:
Bh is the building height
L is the lesser of the building height or projected width. The projected width is the maximum projected width as seen by the stack.

The region of influence of each building is defined as five times L. All stacks located within the region of influence of a building must be considered in the GEP analysis of the stack.

Identify the region of influence for each building on a plot plan. Identify which buildings could influence each of the stacks. For each stack, determine the GEP height by determining the highest GEP height for each building within 5L of the stack. If the stack height is greater than the GEP height, then downwash does not have to be considered.

If the stack height is less than the GEP height, then downwash must be included. The building parameters for the building defining the GEP height are entered on the source line and become the direction-independent variables. In the Jim Clary & Associates software, these parameters are entered along with the other source data through POINTI or SOURCEI.

These direction-independent building dimensions should be based on the maximum projected width as seen by the stack. The building length and width input for the ISCST are 0.886 multiplied by the maximum projected width. POINTI or SOURCEI automatically perform this calculation.

Please note that the methodology described above remains unchanged from the previous versions of the models.

You will now determine if the Schulman-Scire treatment applies. If $Hs < Hb + 0.5 L$ then the Schulman-Scire treatment applies and you must continue with the analysis for this stack. If the Schulman-Scire treatment does not apply ($Hs > Hb + 0.5 L$) then you are finished with this stack. However, if the regulatory default option is used, and if the direction-independent building parameters are non-zero, then you must include dummy lines for the direction-independent building parameters. The Jim Clary & Associates software automatically inserts these dummy lines.

To continue with the Schulman-Scire treatment, you must set the regulatory default option or set the Schulman-Scire option for the stack (screen 13 in the Jim Clary & Associates software), then determine the direction-dependent building parameters for the stack. The methodology is somewhat similar to the method used for the direction-independent building parameters. However, in place of the region of influence of 5L for all directions, the size of this region will become dependent upon the wind direction as follows: The building must be within 0.5L in the crosswind direction; within 2L in the upwind direction, or within 5L in the downwind direction. The direction-dependent building parameters are defined as the building parameters for the structure resulting in the highest GEP stack height that falls within the 0.5L, 2L and 5L region. Remember, you must use the direction-dependent building width in your calculations. These parameters are entered on screen 15 in the Jim Clary & Associates software.

4. VERIFICATION RUNS

Both ISCST and ISCLT runs are discussed in this section. The purpose of these runs is to assess the impact of the downwash method and to identify any possible program error (bugs). The ISCST version is 88207; ISCLT is 88167.

Two simple runs were made. Each run contains thirteen source groups. Each source group contains one source with the following stack parameters:

Stack Height = 50 Meters
Stack Diameter = 0 (no plume rise)
Direction-Independent Building Height (Hb) = 50 meters
Direction-Independent Building Width = 70 meters

Since the building height is less than the building width, L assumes the value of the building height of 50 meters. A simple receptor grid made-up of one column with twenty rows extending to the north of the source. The wind direction is from the south, transporting the plume directly over the receptor grid. Receptors are placed every 100 meters.

The first source group did not use the direction-dependent building parameters. Therefore, this source group represents a Huber-Snyder downwash case using a building height of 50 meters. The only parameter that varies in source groups 2 thru 13 are the direction-dependent building parameters. The direction-dependent building heights varied from 50 to 0 meters. The direction-dependent building width is set to 60 meters in source groups 2 through 13. Therefore, each source group represents a different ratio of building to stack ratio.

Maximum concentrations are determined for each of the source groups and are defined as follows:

Concentration Source Group	Direction-Dependent Building Height (m)	Ratio of Stack to Building Hgt	Maximum ISCST	ISCLT
1	--	N.A.	104.4	3.68
2	50	1.0	76.3	9.03
3	45	1.1	65.3	8.99
4	42	1.2	56.7	8.58
5	38	1.3	73.0	7.95
6	36	1.4	63.6	7.57
7	33	1.5	104.4	7.05
8	31	1.6	104.4	6.53
9	29	1.7	104.4	6.03
10	25	2.0	104.4	4.22
11	20	2.5	104.4	1.61
12	5	10.0	104.4	0.76
13	0	N.A.	104.4	0.76

The following conclusions can be made:

The ISCST model incorrectly applies the Huber-Snyder treatment even though the direction-independent building parameters are below the Huber-Snyder region. For example, source groups 12 and 13 should be equal to the non-downwash case, not the Huber-Snyder case. Therefore, concentrations may be over-estimated in ISCST when Hs › Hb(d) + 1.5 L(d).

The ISCLT model appears to use the direction-dependent building parameters when the Huber-Snyder treatment should be applied using the direction-independent building parameters. Source groups 8 thru 10 should yield the same concentrations, as the Huber-Snyder treatment should be used. Therefore, concentrations may be under-estimated or over-estimated when Hs › Hb(d) + 1.5 L(d).