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GIS Symbology for FRMAC/CMHT Radiological/Nuclear Products

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Introduction

This document is intended to codify, to the extent currently possible, the representation of map products produced for and by the Federal Radiological Monitoring and Assessment Center (FRMAC) and the Consequence Management Home Team (CHMT), particularly those that include model products from the National Atmospheric Release Advisory Capability (NARAC). This is to facilitate consistency between GIS products produced by different members of these teams, which should ease the task of interpreting these products by both team members and those outside the team who may need to use these products during a response. The aspects of symbology being considered are primarily isopleths levels (breakpoints) and colors used to plot NARAC modeled dose or deposition fields on mpas, although some comments will be made about the handling of legend and supporting textual information. Other aspects of symbolizing such products (e.g., transparency) are being left to the individual team members to allow them to adapt to particular organizational needs or requirements that develop during a particular a response or exercise.

This document has been written in coordination with the creation of training material in Baskett, et al., 2008. It is not intended as an aid to NARAC product interpretation but to facilitate the work of GIS specialists who deal with these products in map design and in the development of supporting scripts and software that partially or completely automate the integration of NARAC model products with other GIS data. This work was completed as part of the NA-42 Technical Integration Project on GIS Automated Data Processing and Map Production in FY 2008. Other efforts that are part of this work include (a) updating the NARAC shapefile product representation to facilitate the automation work proceed at RSL as part of the same TI effort and (b) to ensure that the NARAC shapefile construct includes all of the necessary legend and other textual data to interpret dispersion and deposition patterns and related products correctly.

This document is focusing on the products produced by the GIS Division of the Remove Sensing Laboratory (RSL) and by the National Atmospheric Release Advisory Center (NARAC), both separately and in combination. The expectation is that standard products produced by either group independently or in combination should use the same key attributes in displaying the same kinds of data so that products of a given type generally look similar in key aspects of the presentation, thereby minimizing any confusion of users when a variety of products from these groups may be needed.

This document is dealing with the set of common standard products used in responding to radiological/nuclear releases. There are a number of less standard products that are used occasionally or in certain specific situations that are not addressed here. This includes special products that are occasionally produced by both NARAC and RSL in responses and major exercises to meet immediate and unanticipated requirements.

At some future time, it may be appropriate to review the handling of such special products by both organizations to determine if there are any areas that would benefit from being integrated with the conventions described here. A particular area that should be addressed in the near-term is that of Derived Response Levels (DRLs) calculated by the Consequence Management Home Team (CMHT) or FRMAC Assessment Scientists. A new calculation is done for every event assigning contour levels, or break-points, based upon field measurements. These contour levels can be applied to deposition or dose rate NARAC calculations. Because these calculations are different every time, they can not be stored in a database.

Background

NARAC Products

NARAC produces a variety of products intended to meet the needs of a wide range of customers and response situations. These products represent the consensus of the NARAC user community and sponsoring agencies. The central component of most NARAC products is a map of key information such as a dispersion pattern or measurement values. These maps include a base map of features such as streets that provide a geographic reference along with a legend and other textual information that allow the product to be interpreted by knowledgeable users. Different versions of the textual information and other details are defined to tailor products for different user groups. In particular, "technical" products are generated for scientific users and "briefing" products are generated for more general users such as incident commanders and other government officials. In addition to being used independently, the basic map product can used as a component of more complete consequence reports that include information on model inputs, data sources and assumptions, along with guidance that allows the products to be interpreted correctly by less experienced users.

For each type of release scenario supported, a specific set of products are defined that are produced automatically. These "default" products are generated for and sent to NARAC Web and iClient users when they submit a model request. These default plots provide a basic view of the situation and are adequate for training, initial response and simple exercises but are typically insufficient to meet all the needs of larger exercises or real responses. Table 1 shows the types of default products provided for each release type that

is associated with radiological/nuclear responses. The suite of models maintained as part of the NARAC Central System can produce many products in addition to those generated by default. The NARAC Operational Scientists can produce such products as needed during a response or exercise and share them with customers via the NARAC Web or iClient. In addition to providing an extended range of products, NARAC Operations provides other reachback support to produce refined predictions based on field measurements, more accurate descriptions of the source and release mechanisms, improved meteorological or other data. These refined products, once approved, are shared with authorized users as above.

Release Type	Default Plot Type
Unknown source material	Hourly average air concentration Deposition if particulate is used
Radiological	Dose, dose rate, deposition
High-Explosive	Health effects from blast overpressure
Nuclear Detonation	Prompt effects, dose, dose rate

Table 1. Standard Default Plots for Radiological/Nuclear Release Types

There are a number of components that comprise a NARAC map that provide the information necessary to interpret the map. Figure 1 shows an annotated example of a typical map product. The map is supported by a legend showing the isopleths/contour levels of dose, dose rate or deposition ("break points"), colors, area covered and the time-averaged population included within the contour. The area above the map and legend contains the plot title and subtitle, the run title and the response level. The area below the map contains contact and identification information that allow the product to be matched with the requestor and approver as well as a reference to internal NARAC constructs so that detailed questions can be addressed by NARAC staff. The area below the legend indicates the time range associated with the product (many NARAC products are accumulations over time and so describe a time range, not a single point in time), along with information about the source material and location. A comments section is more free-form and may contain whatever information is viewed as most useful to users of a product such as the source amount, duration of release and the type of meteorological data used. The information on the 1-page NARAC product is carefully chosen to be the minimal acceptably complete description of the product to be correctly used by a knowledgeable user and it is important that all the information be displayed in GIS products that use a NARAC model prediction as a component of the display.
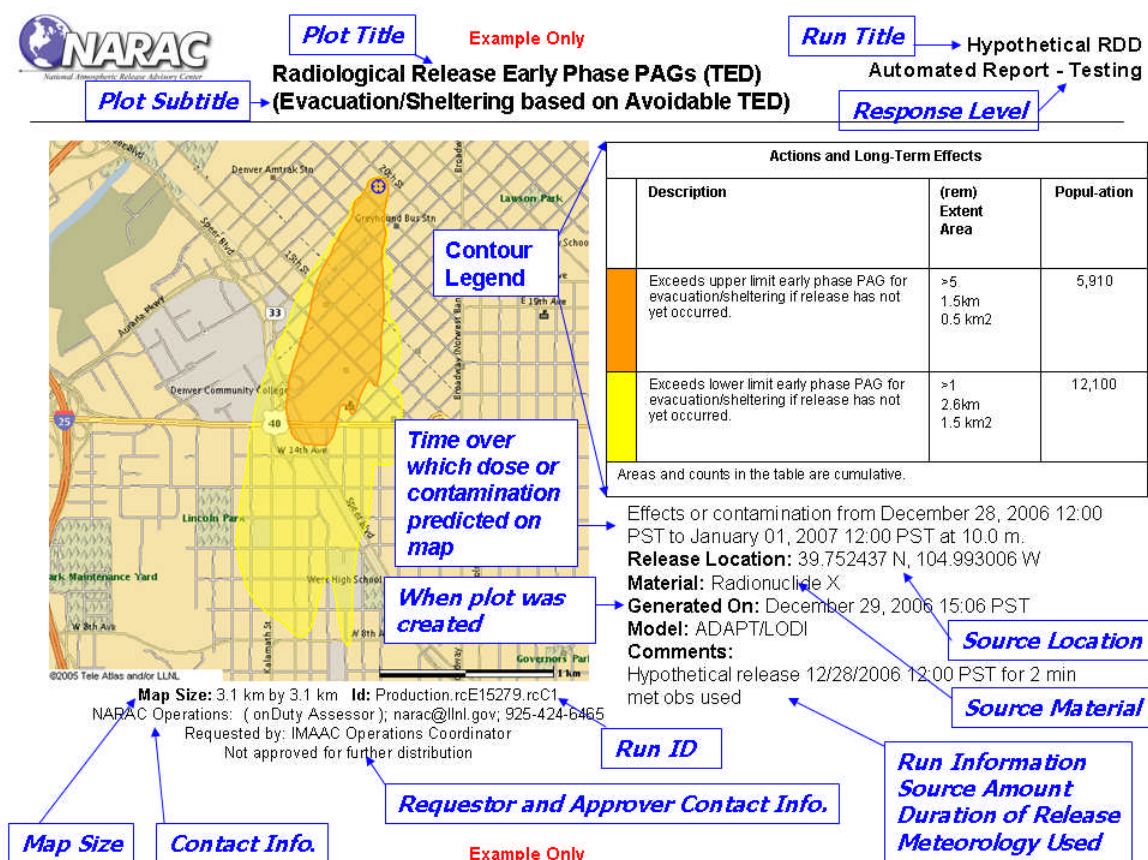
Figure 1. Annotated example of a NARAC product.

RSL GIS Products

RSL GIS map products use various data sources such as measurement data and NARAC model products to produce high-quality map using ESRI software tools. Traditionally, the RSL focus has been on large-format presentations targeted at technical staff although recent work has included the ability to generate page-size formats and presentations that are oriented towards more general audiences ("briefing products"). Regular interaction between RSL and NARAC has been and will be required to ensure that the full range of FRMAC and CHMT products are consistently represented.

Relationship between NARAC and RSL Products

Given some differences in the audiences for RSL and NARAC products, some differences in the material presented and differing production technologies, it is unsurprising that these products have used different layouts in the past. With respect to many details, these differences do not have a major impact. However, a few aspects of the presentation have been identified that can cause significant confusion if they are not coordinated between the two organizations. In particular the isopleths levels/break points and the colors of the contour areas or measurements are especially important in ensuring that equivalent or combined products from NARAC and RSL can be interpreted easily

and consistently by customers. It is also important the RSL products that contain NARAC model results include most or all of the legend and annotation information displayed on the NARAC one-page presentation illustrated in Figure 1, such as the plot titles and subtitles.

The transfer and management of this information between NARAC and RSL is the focus of other work that is part of the same TI effort. Details of the display of NARAC legend and annotation information on RSL plots are being worked out but there is a reasonable degree of flexibility in many details of the symbolization of this information. For example, the exact positioning, text fonts, text size are left unspecified by this document to allow flexibility in meeting the requirements of the different organizations. Thus, most of this document will be focused on specification of the break points and colors for of the major types of NARAC products typically used in radiological/nuclear responses. These include measurement products that can be produced by either organization independently.

NARAC Contour Level Conventions

Before looking at the various products of interest here, it is appropriate to describe some conventions for selecting contour levels that have developed over time in the NARAC system to meet the range of situations that commonly arise. Contour levels are determined in two ways:

1. Specified – values are defined by external organizations or customers

2. Calculated – values are defined relative to the maximum value in the dispersion pattern. Typically, the three largest decades less than the maximum value are used. For example, if the maximum value is 3.7e-5, the contour levels would be 1.0e-5, 1.0e-6 and 1.0e-7.

Specified contour levels are categorized in to two ways. First, levels can be administered on the basis of guidance from organizations that have oversight over the consequences of certain hazards such as the Environmental Protection Agency (EPA), the Nuclear Regulatory Commission (NRC) and the Food & Drug Administration (FDA). These are maintained in databases in the NARAC System. Second, contour levels can also be specified by a particular customer to meet their individual needs. These two categories are symbolized differently. Note also that for specified levels to be applicable, some knowledge of the source term must be available.

Given specified contour levels, it is possible that the NARAC dispersion model simulations may not identify any area that reaches the lowest of these levels. While such an occurrence does mean the product does not represent a situation of official regulatory interest, it is important for a number reasons to produce a representation of the dispersion pattern, e.g., to facilitate monitoring surveys to confirm levels of contamination/dose. In such cases the contour levels are "recomputed", i.e. they are calculated on the basis of the maximum value in the dispersion pattern as described above. Table 2 summarizes the general NARAC contour coloring conventions.
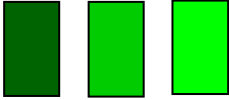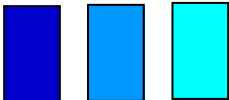
Levels	Levels reached?	Contour Colors [with RGB values]	Description
Source term exists Administered levels: Acute/Chronic exposure/dose or protective action guide levels	Yes	[153,0,0] [255,0,0] [255,150,0] [255,205,0] [255,255,0]	Consistent with EPA, NRC, FDA or other guidance.
	No	[0,102,0] [0,204,0] [0,255,0]	May be below health effect or PAG levels. Possibly contaminated area.
Source term estimate used Customer specified levels	Yes	[102,0,102] [255,0,255] [255,153,255]	Customer specified levels.
	No	[0,0,204] [0,153,255] [0,255,255]	Below customer specified levels.
Source term estimate unavailable No levels specified		[51,51,51] [102,102,102] [153,153,153]	No guidelines specified. Possibly contaminated area.

Table 2. NARAC contour color conventions

NARAC Radiological Product Symbology
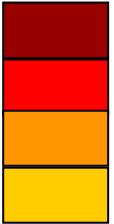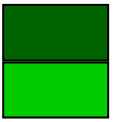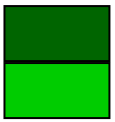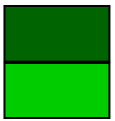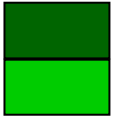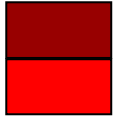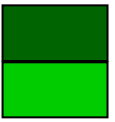
Following are tabular descriptions of the various products that are available for use during a radiological/nuclear response. These tables are organized by the category of release scenario where they are applicable.
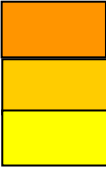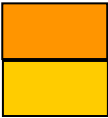
Unknown Source Material

Plot type (shapefile field)	Units	Level type	Contour levels	Recomputed contour levels
1 Hr Avg Air Conc	g/m^3	calculated	$>10e^n$ ⬛ $>10e^{n-1}$ ⬛ $>10e^{n-2}$ ⬛ $(10^n < \text{maximum})$	*Not applicable*
Total Deposition of Particulate	g/m^2	calculated	$>10e^n$ ⬛ $>10e^{n-1}$ ⬛ $>10e^{n-2}$ ⬛ $(10^n < \text{maximum})$	*Not applicable*

Radiological Release

Plot type (shapefile field)	Units	Level type	Specified Contour levels	Recomputed contour levels (if all values less than specified values)
Total Effective Dose Equivalent -------- Radiological Release Dose Including Plume Passage -------- Radiological Release Early Phase PAGs (TED)	rem	administered	>5 🟧 >1 🟨	$>10e^{n-1}$ 🟩 $>10e^{n-2}$ 🟩 $(10^n < \text{maximum})$

Radiological Release Deposition	$\mu Ci/m2$	calculated	$>10e^{n}$ (dark gray) $>10e^{n-1}$ (gray) $>10e^{n-2}$ (light gray) ($10^{n} <$ maximum)	*Not applicable*
Radiological Release Groundshine Dose Rate at 1 Day (worker levels)	rem/hr	administered	>25 (dark red) >10 (red) >5 (orange) >2.5 (amber)	$>10e^{n-1}$ (dark green) $>10e^{n-2}$ (green) ($10^{n} <$ maximum)
Radiological Release Groundshine Dose Rate at 1 Day (NRC)	rem/hr	administered	>0.002 (yellow)	$>10e^{n-1}$ (dark green) $>10e^{n-2}$ (green) ($10^{n} <$ maximum)
Emergency Worker Does Rate (Near Field)	rem/hr	administered	>100 (dark red) >50 (red) >25 (orange) >10 (amber) (yellow)	$>10e^{n-1}$ (dark green) $>10e^{n-2}$ (green) ($10^{n} <$ maximum)
Emergency Worker Does Rate (Far Field)	rem/hr	administered	>10 (dark red) >1 (red) >0.1 (orange) >0.01 (amber) >0.002 (yellow)	$>10e^{n-1}$ (dark green) $>10e^{n-2}$ (green) ($10^{n} <$ maximum)
Radiological Release Early Health Effects (organ dose)	rad equivalent	administered	$>50\%$ fatalities (dark red) $>$ fatality onset (red)	$>10e^{n-1}$ (dark green) $>10e^{n-2}$ (green) ($10^{n} <$ maximum)
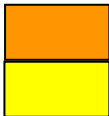
Radiological Release Early Phase Guidance (Radioiodine)	rem	administered	>500 >10 >5	*Not applicable*
Nuclide Contamination Areas of Concern (food ingestion)	pCi/m2	administered	>FDA milk >FDA produce	*Not applicable*
Radiological Release Intermediate Phase PAGs (1-2 year)	rem	administered	>2 >0.5	*Not applicable*
Radiological Release Intermediate Phase Dose (50 year)	rem	administered	>5	*Not applicable*

Release with High Explosive

Plot type (shapefile field)	Units	Level type	Contour levels	Recomputed contour levels
Blast Effects from High Explosives	psi	calculated	>100 >25 >10 >5 >0.5	*Not applicable*

Nuclear Yield

Plot type (shapefile field)	Units	Level type	Contour levels	Recomputed contour levels
Prompt Nuclear Detonation Pop. Effects	psi	administered	>90% fatalities >50% fatalities >10% fatalities >50% injuries >10% injuries	*Not applicable*
Prompt Thermal Effects on Personnel	cal/cm2	administered	third deg. burns second deg. burns first deg. burns	*Not applicable*
Prompt Nuclear Detonation Heavy Structure Effects	psi	administered	>54.7 >33.4 >24.2 >20.5 >15.5	*Not applicable*
Prompt Nuclear Detonation Light Structure Effects	psi	administered	>7.4 >5.7 >5.0 >4.4 >3.7	*Not applicable*

Nuclear Detonation Early Pop. Effects (1 day)	rad	administered	>450 ■ >300 ■ >200 ■ >150 ■ >100 ■		*Not applicable*
Nuclear Detonation Groundshine Dose (evacuation)	rem	administered	>5 ■ >1 ■		*Not applicable*
Nuclear Detonation Groundshine Dose Rate (6 hours)	rem/hr	administered	>25 ■ >10 ■ >5 ■ >2.5 ■		*Not applicable*

Summary

The preceding tables represent the current range of standard products available from NARAC as part of a radiological/nuclear response. Note that the suite of supported products will tend to grow over time and details of the symbology will evolve for a variety of reasons, e.g. guidance from an organization may change, so this document should be reviewed and updated on a regular basis. As mentioned in the introduction, there is additional work that could be done from this starting point to begin to standardize aspects of the presentation of other non-standard products such as Derived Response Levels. This will require continued collaboration between NARAC and RSL.

Cited References

R.L. Baskett, B. Pobanz, J.Nasstrom, K.T. Foster, NARAC Standard Products and Interpretation, UCRL-PRES-231718, 2008.