

Emergency Road Damage Assessment (ERDA) Resource



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Background

Over the last decade the Santa Cruz County has experienced several natural disasters (fires and extreme weather events) resulting in damage of varying degree to the county's road network. The Emergency Road Damage Assessment (ERDA) Resource was developed under the direction of the Board of Supervisors with input from the CEO's office, the OR3 and Public Works to provide a transparent and objective methodology for assessing emergency road damage on county-maintained roads.

The ERDA Resource uses data collected by Public Works field crews and GIS technology to calculate an assessment score for each road damage location. There are six criteria used in the calculation that are weighted, normalized and combined into a final 1 -100 assessment score (one being lowest and 100 being highest). The ERDA Resource is designed to support decision making; however, it is not intended to be deterministic. There are factors beyond the criteria used by the ERDA Resource that can affect how emergency road damage is evaluated, such as cost, access, safety, or proximity to other damage locations.

ERDA Resource

During and after an emergency, Public Works Road crews are dispatched to evaluate damage to the county's road network. The road damage locations and related information are entered into the Central SquareEAM system (formerly known as Lucity Asset Management) and then processed by the ERDA Resource to assign an assessment score for each road damage location.

Four of the six criteria used to calculate the assessment score are based on existing data developed by the [Climate Adaptation Vulnerability Assessment](#) (CAVA). The emphasis of CAVA was to identify transportation infrastructure assets in the county that may be particularly vulnerable to climate hazards.

The remaining two criteria require each site to be evaluated by Public Works staff to determine the type and extent of road damage.

Data Inputs

Four CAVA Criteria:

Travel Volume Score ranges from 3–10. The primary input was raw travel volumes from the Santa Cruz County travel demand model. This variable is weighted to represent 15% of the total score.

Detour Time Score ranges from 1–5 and is derived from estimating detours using Google Map calculations for all roads outside of urbanized areas that appear to have detour times greater than 4 minutes. This is the most heavily weighted score (28% of the total score) in consideration of potential extended and onerous detour times.

Access/Functional Needs Score ranges from 0–10 based on overlays with disadvantaged community mapping from the Census Bureau’s American Community Survey (ACS) data. This variable represents 12% of total score.

Critical Facilities Score ranges from 0–2 based on whether the road provides primary (coded 2) or alternate (coded 1) access to one or more county designated critical facilities. This variable represents 12% of total score.

For a more detailed description of the CAVA criteria see [Appendix 1](#).

Two Public Works Criteria:

Loss of Lane Score ranges from 1–5 points:

- 5 = Road Closed
- 2 = Lane Closed (1/2 roadway)
- 1.5 = Lane Closed
- 0.5 = Shoulder Closed
- 0 = Damaged Embankment

Loss of lane score is weighted to represent 25% of the total score because it considers the extent of damage to the road in terms of its continued useability.

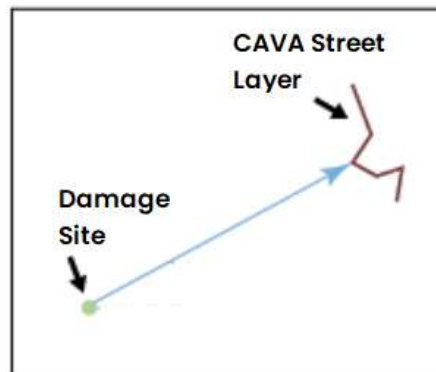
Compromised Utilities/Culverts Score ranges from 0 – 3, and includes infrastructure such as water, sewer, storm drains, franchise lines such as electrical, phone and cable service, etc. The point scale is as follows:

- 3 = Utilities Damaged
- 2 = Utilities Compromised
- 1 = Culvert Damage
- 0 = Culvert Compromised

The Compromised Utilities/Culverts score is weighted to represent 8% of the total score.

Workflow

- 1.) Emergency Road Damage data is collected by Public Works and fed into a GIS layer of road damage sites.
- 2.) The damage sites layer is processed against the CAVA street layer containing the CAVA criteria scores. The CAVA streets layer has the four CAVA criteria “baked in” and they are transferred to the damage site based on proximity (damage sites take on the nearest street segments CAVA scores).



- 3.) The ERDA Resource steps through each damage site, zooms to the road damage site and provides an interface for staff to input the Loss of Lane and Compromised Utilities/Culverts scores.
- 4.) Once all scores are entered, the score for each criterion is converted to a common scale based on its percentage weight and the assessment score between 1-100 is calculated (see Appendix 2 for example calculation).
- 5.) The criteria are recorded and exported as a PDF report file that creates a record of the assessment scores at a given time and date.
- 6.) The data is grouped into 4 categories and symbolized on a map and included in the ERDA Resource Dashboard.
 - Highest = Assessment Score 45 – 100
 - High = Assessment Score 35 – 45
 - Medium = Assessment Score 25 – 35
 - Low = Assessment Score 0 – 25

Appendix 1. CAVA Data Inputs Detailed Description

Relative travel volume score was developed based on several variables. The primary input was raw travel volumes from the Santa Cruz County travel demand model. This required a crosswalk between the county roads linework and model volumes, which were on a different linework. Spatial joins and road names were used to crosswalk the data.

The base case year of 2019 was used from the travel demand model. Line segments for volume data and study road data were spatially joined at a 25' threshold. Matches from the spatial join were verified by matching the road name identifiers in both datasets and taking the average from both directions of travel. Spot checking of this process seemed reasonable in most places, though this process is prone to error, and the entire network was not reviewed in detail.

A majority of roads needed to be gap filled, which was done using the 'FHWA_Desc' roadway types. The 10th percentile was calculated for each roadway type and applied to fill gaps (done assuming roads without volume values tended to be lower travel volumes).

After the volume was estimated for each road segment, scores were created according to the following methodology:

- 3 = Low Volume (less than 1,000 trips) group 1, includes roads less than 150', dead-end segments and access to less than 6 residences that DO NOT provide access to critical facilities, businesses or other potentially high travel destinations.
- 5 = Low Volume group 2, includes travel volumes less than 1,000 but are categorized by FHWA as "local".
- 6 = Low Volume group 3, includes travel volumes less than 1,000 but are categorized by FHWA as something other than "local" (e.g. minor or principal arterial, collector, etc.).
- 7 = High Volume group 1, includes volumes greater than 1,000 but less than 2,500 trips.

- 8 = High Volume group 2, includes volumes greater than or equal to 2,500 and less than 5,000 and less than 10,000.
- 9 = High Volume group 3, includes volumes greater than or equal to 5,000 and less than 10,000.
- 10 = High Volume group 4, includes volumes greater than or equal to 10,000 trips.

Santa Cruz County access/functional needs criteria score is assigned per the local definition confirmed by RTC. A score of 10 is more disadvantaged and 0 is less disadvantaged. Scores were capped at 10. Scoring is based on overlays with disadvantaged community mapping, which was derived from American Community Survey (ACS) data. Assets intersecting low-mobility tracts outside of the rural and urban services boundaries received 1 extra point for this metric (per one of the 3 RTC defined criteria for disadvantaged communities).

Detour time (in minutes). Manual detours using Google Maps were calculated for all roads outside of urbanized areas that appear to have incremental detour times greater than 4 minutes. This metric reflects detours around segments of interest and account for detour time subtracted from no-detour time for a typical Wednesday at 8am. One way in/out roads without detours are also included.

- 1 = 0-10 minutes
- 2 = 10-15 minutes
- 3 = 15-20 minutes
- 4 = 20-25 minutes
- 5 = Anything over 25 minutes or one/way in/out

Critical facilities. Road segments were flagged that appear to provide primary (coded 2) or alternate (coded 1) access to one of the critical facilities identified in the county's facilities layer.

Appendix 2. Example Assessment Score Calculation

To leverage the existing score values and ranges provided with the CAVA criteria and to help develop a meaningful metric, the raw scores for each criterion are weighted (given the percentage they contribute to the score), normalized, then combined to create a 1-100 assessment score for each site.

	<u>Maximum Raw Score</u>
Travel Volume	=10
Detour Time	=5
Loss of Lane	=5
Compromised Utilities/Culverts	=3
Access and Functional Needs	=10
Critical Facilities	=2

The maximum raw score is the sum of the maximum raw scores for each criterion and equals 35 (10 + 5 + 5 + 3 + 10 + 2). The criteria are weighted as follows:

Criteria Weights

Travel Volume weighted at 15%.

Detour Time weighted at 28%.

Loss of Lane weighted at 25%.

Compromised Utilities/Culverts weighted at 8%.

Access and Functional Needs weighed 12%.

Critical Facilities weighted at 12%.

To apply the weighting (as percentages) and convert to a normalized 1 –100–point scale the following steps must be taken:

- 1) Convert the maximum raw score for each criterion to a maximum weighted score. Maximum raw score value multiplied by weight (percentage) equals the maximum possible score on weighted scale.

		<u>Maximum Weighted Score</u>
Travel Volume	35 x .15	= 5.25
Detour Time	35 X .28	= 9.8

Loss of Lane	$35 \times .25$	$= 8.75$
Compromised Utilities/Culverts	$35 \times .08$	$= 2.8$
Access and Functional Needs	$35 \times .12$	$= 4.2$
Critical Facilities	$35 \times .12$	$= 4.2$

- 2) Divide the raw score for each criterion by the maximum raw score for the criteria, then multiply by the maximum weighted score for the criteria to get the weighted scores. Samples raw scores (of 3,4,2,2,3,2) are used below.

	<u>Weighted Scores</u>
Travel Volume score of 3 would be $3/10 \times 5.25$	$= 1.575$
Detour Time score of 4 would be $4/5 \times 9.8$	$= 7.84$
Loss of Lane score of 2 would be $2/5 \times 8.75$	$= 3.5$
Utilities score of 2 would be $2/3 \times 2.8$	$= 1.87$
Access and Functional Needs score of 3 would be $3/10 \times 4.2$	$= 1.26$
Critical Facilities score of 2 would be $2/2 \times 4.2$	$= 4.2$

- 3) To convert to a normalized 1 –100 score, take each weighted score, divide by 35 (the maximum raw criteria score), then multiply by 100.

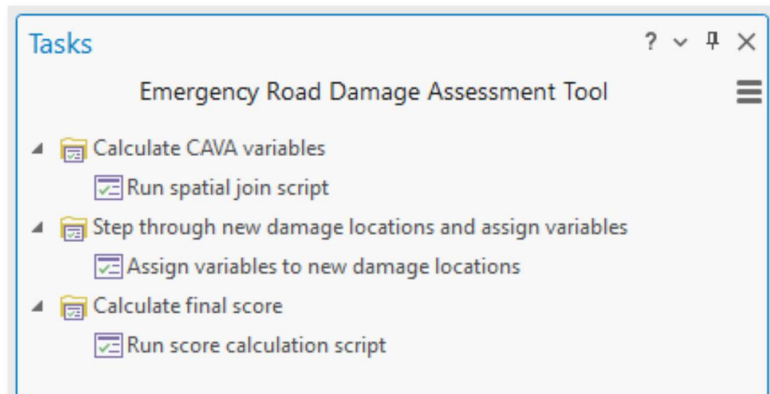
	<u>Normalized Scores</u>
Weighted Travel Volume of $1.575/35 \times 100$	$= 4.5$
Weighted Detour Time of $7.84/35 \times 100$	$= 22.4$
Weighted Loss of Lane of $3.5/35 \times 100$	$= 10$
Weighted Utilities value of $1.87/35 \times 100$	$= 5.34$
Weighted Access and Functional Needs of $1.26/35 \times 100$	$= 3.6$
Weighted Critical Facilities of $4.2/35 \times 100$	$= 12$

- 4) Then sum up the normalized scores to get the normalized assessment score.
 $4.5 + 22.4 + 10 + 5.34 + 3.6 + 12 + 3.6 + 12 = \mathbf{57.84}$

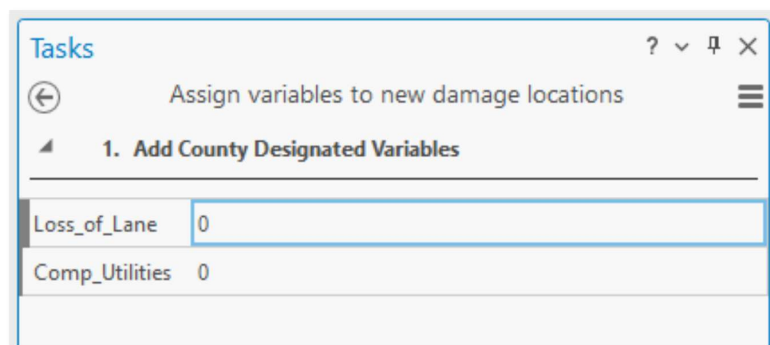
The normalized assessment scores are sorted in descending order listed in the Road Damage Assessment Report (see appendix 4).

Appendix 3. Task Functionality

The ERDA Resource is a collection of customized scripts and geoprocessing tools that are assembled into a custom ArcGIS Pro Task. This task is comprised of 3 task groups:



1. "Calculate CAVA variables" runs a script that copies the 4 CAVA variables into the Road Damage feature class.
2. "Step through new damage locations and assign variables" runs a series of steps that allows the user (Public Works engineer) to step through each damage location and assign the 2 site specific variables (extent of the loss of lane(s) and whether utilities are affected):



3. "Calculate final score" runs a script that calculates the final score once all the required variables exist for each damage location. After the final assessment

score is calculated, another script is automatically executed that creates a report that is a log of the criteria used at the time the score was calculated.

Appendix 4. Sample Report

Final Score	(Old DPW Score)	CAMS #	Road	Location	Description	Storm Year
69.1	(8)	P42308	EUREKA CANYON RD	0.35	40 foot long slipout, 3 ft into road	2023
CAVA Variables	Critical Facilities: 12	Travel Volume: 9	Access and Functional Needs: 4.8	Detour Time: 28		
County Variables	Loss of Lane: 10	Compromised Utilities/Culverts: 5.33		FEMA Eligible: No		
65.9	(9)		NELSON RD	0.44	road washout due to clogged culvert/	2017
CAVA Variables	Critical Facilities: 0	Travel Volume: 7.5	Access and Functional Needs: 2.4	Detour Time: 28		
County Variables	Loss of Lane: 20	Compromised Utilities/Culverts: 8		FEMA Eligible: Yes		
62	(10)	P42567	REDWOOD LODGE RD	2.02	Road settlement from 2017 repair site	2023
CAVA Variables	Critical Facilities: 0	Travel Volume: 9	Access and Functional Needs: 0	Detour Time: 28		
County Variables	Loss of Lane: 25	Compromised Utilities/Culverts: 0		FEMA Eligible: No		
62	(12)	P42324	REDWOOD LODGE RD	1.80	Culvert/bridge failure	2022-2023
CAVA Variables	Critical Facilities: 0	Travel Volume: 9	Access and Functional Needs: 0	Detour Time: 28		
County Variables	Loss of Lane: 25	Compromised Utilities/Culverts: 0		FEMA Eligible: No		
60.3	(10)	P42471	REDWOOD RD	??? 0.05		2023
CAVA Variables	Critical Facilities: 0	Travel Volume: 7.5	Access and Functional Needs: 4.8	Detour Time: 28		
County Variables	Loss of Lane: 20	Compromised Utilities/Culverts: 0		FEMA Eligible: Yes		
59	(10)	P42581	UPPER EAST ZAYANTE	2.51		2023
CAVA Variables	Critical Facilities: 12	Travel Volume: 9	Access and Functional Needs: 0	Detour Time: 28		
County Variables	Loss of Lane: 10	Compromised Utilities/Culverts: 0		FEMA Eligible: No		