Keeping a shelter supplied after a tornado

Water, communications and power during the first 24 hours

Southern Maryland | 10 October 2026

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01

Bottom line up front (BLUF)

This study examines water supply and communications for a **39-person shelter** during a 24-hour disruption in southern Maryland. The scenario applies documented effects of the 2002 La Plata tornado to modern geography and assumed response resources.

Early requests prevented the main scenario's water shortage. Requesting the day's remaining need at the start also reduced vehicle travel. This result depended on a usable delivery route. [10]

Stored water covered the tested eight-hour closure. With all access blocked, a confirmed request could not restore supply. Water already at the shelter covered demand until unloading. The same supply fell short during longer closures under a different consumption pattern. [10, 12]

Internet equipment required more battery energy than radio. The larger battery sustained the full-day test; the smaller battery could not support internet equipment for 24 hours. These results apply to the equipment loads represented in the model. [10]

02

Problem statement

The problem is to maintain drinking-water availability while normal communications and road access are disrupted. The study compares request timing, stored water and backup power across assumed access conditions. Each supply request is followed through confirmation, dispatch, travel and unloading.

Shelter support depends on confirmed requests and enough water to cover the delivery delay.

This is a planning exercise with assumed resources. It covers drinking water, short messages and power for communications over one day. The quantities are scenario results; using them at a real shelter requires local checks.

03

Scenario

The exercise places the shelter at **Thomas Stone High School** in Waldorf, which also sheltered people in 2002. The **Department of Emergency Services on Audie Lane** in La Plata coordinates deliveries. **Charles County Fairgrounds** holds the supplies. Their modern activation and resources are assumed. [2, 4, 9]

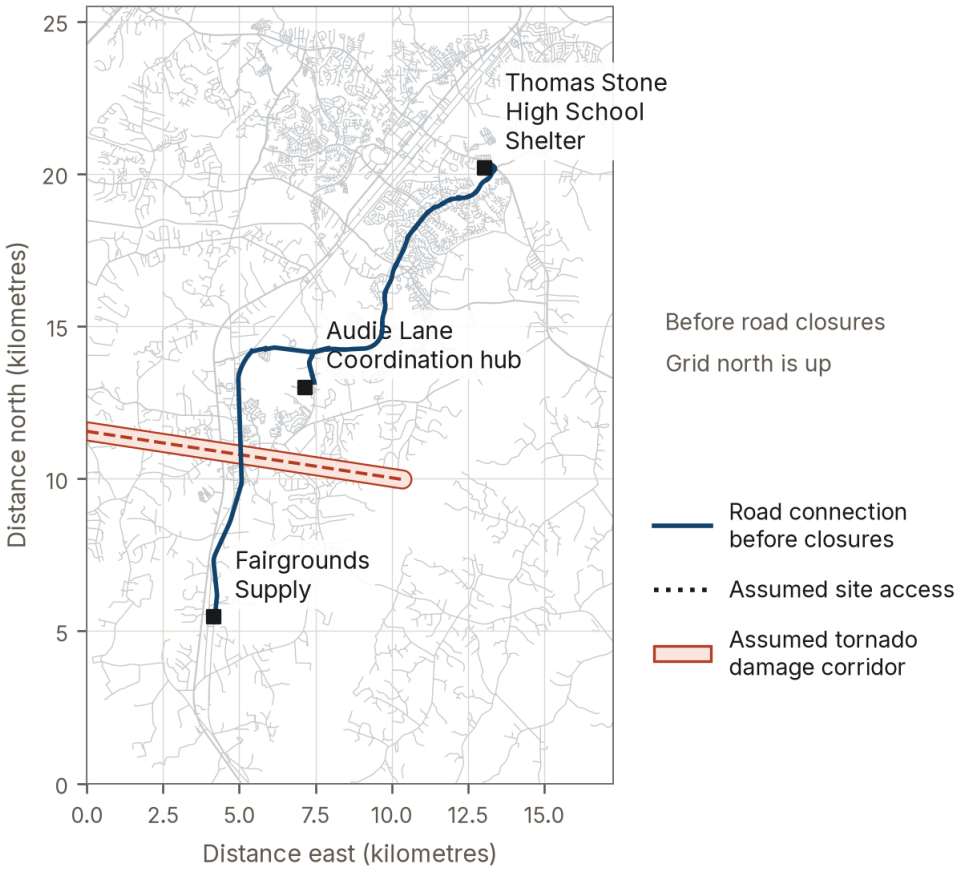


Figure 1. Three sites and the assumed tornado damage corridor. Blue lines follow mapped roads before closures; they are reference connections, not the vehicle trips reported later. Dotted site connections are assumed access. Red-orange marks the assumed tornado damage. Distances use a local grid. [1, 3, 4, 9]

Documented in 2002	Assumption in the modern scenario
Phone service failed and cellular networks overloaded. [2]	Normal connections are unavailable for 24 hours; replacement links are assumed available.
Debris blocked streets and rescue vehicles. [2]	Road closures disrupt deliveries. Added tests block all shelter access for 8, 10 or 12 hours.
Water-system damage and loss of power disrupted services. [2]	The shelter uses stored drinking water and battery-powered communications.

The historical event supports these disruption mechanisms. It does not establish the model's exact road closures, current facilities, attendance or equipment. Appendix A gives further historical context.

04

Assumptions

The main scenario represents **39 people over 24 hours**. Time is measured from the start of the outage. Other population estimates and technical settings were also tested; the full design is in Appendix A.

Assumption	Effect on the results
People and water	19 people arrive after one hour and 20 after three hours. The model allows 4 litres (L) of drinking water per person for the day: 156 L in total. This excludes other shelter water uses.
When water is used	Original cases use equal amounts every four hours. A later check spreads the same 156 L through the day according to the people present. Neither pattern is measured shelter demand.
Road access	Roads in the assumed tornado corridor close for eight hours. The main scenario has another usable route. Added tests close every shelter approach for 8, 10 or 12 hours.
Supplies and transport	One van and 600 L at the supply point are available. Loading and unloading each take five minutes. Starting water at the shelter changes between comparisons.
Communications and power	The three sites lose normal network connections and grid power for a day. Assumed radio links carry spoken messages or short text updates; internet uses a separate connection. Equipment is ready at the start, with batteries and no generator.

The 39-person attendance is a chosen estimate, not a forecast or a verified school capacity. Actual attendance, usable space, vehicle access and communications performance remain unknown. Appendices A and B retain the detailed choices. [5, 9, 10, 12]

05

Study design (run matrix)

Comparison	Purpose
Request timing and starting water	Assess how earlier requests and additional stored water affect shortages.
Longer road closures	Determine whether stored water lasts through arrival and unloading.
Communications and batteries	Check whether the selected equipment can operate for 24 hours.

A case is one simulated day. The study contains 123 original cases, 24 added timing comparisons and three time-resolution checks. Targets are no water shortage when due, confirmation of eight common messages within five minutes, and no loss of communications power at any site. [10, 12]

06

Findings

Early requests prevented a shortage when a route was available

Both cases start with 19.5 L for 39 people. One requests additional water after a shortage; the other requests the remaining day's need at the start. A usable delivery route remains in both cases. [10]

Water unavailable when needed is the amount the model cannot supply at the time it is due. A later delivery does not erase that earlier shortage. Driving distance, in kilometres (km), includes the vehicle's return within the first day.

When the shelter requests water	Water unavailable (L)	Driving distance (km)
After a shortage	78.0	238.4
At the start	0.0	67.8

Table 1. Same 39 people, 19.5 L starting stock, radio arrangement and larger battery. Only the request rule changes. [10]

Early requests removed the 78 L shortage and reduced driving from 238.4 km to 67.8 km. Requesting the known daily need avoided repeated trips after shortages. Reduced vehicle use could leave the van available for other tasks; those tasks were not simulated.

Stored water covered the wait when all access was blocked

The isolation comparison blocks every shelter approach for eight hours. Both cases request water at the start; initial supply is 19.5 L in one case and 52 L in the other. Daily water need remains 156 L. [10]

Water already at the shelter (L)	Water unavailable when needed (L)
19.5	32.5
52.0	0.0

Table 2. Same 39 people, early request and eight-hour closure. Water is used at four-hour intervals. Radio and radio plus internet give these same water results and confirm all eight common messages in time. [10]

Holding 52 L on site removed the 32.5 L shortage during the delay. Both communications options confirmed the requests, but deliveries remained blocked by road access. Stored water must cover demand through arrival and unloading.

06 / continued

Findings

Water must last until the delivery is unloaded

Both requests are confirmed after 25 seconds. The model withdraws 26 L at hours 4, 8, 12, 16, 20 and 24. Starting with 52 L covers the first two withdrawals; 19.5 L does not. [10, 12]

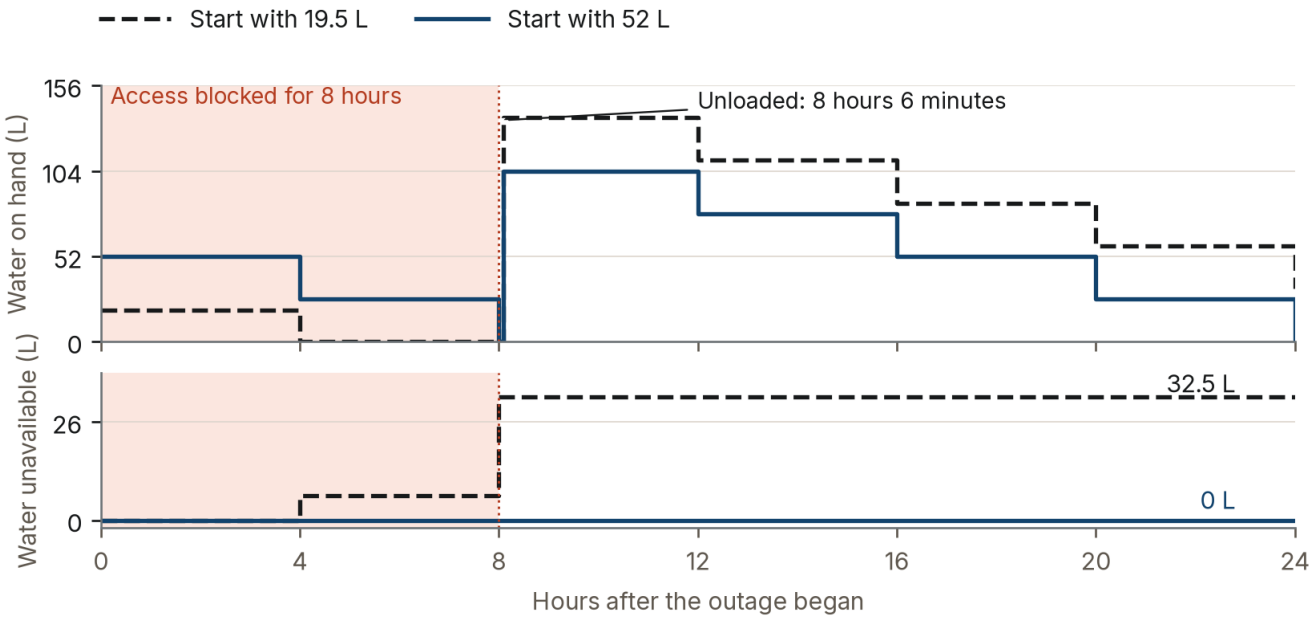


Figure 2. Starting supply and water availability during blocked access. Both lines describe the same 39-person scenario with an early request. Steps show withdrawals or delivery. Access returns after eight hours; unloading finishes about six minutes later. [10, 12]

Longer closures expose a shortfall in the same supply

A second consumption pattern spreads the same 156 L across the hours people are present. **With a ten-hour closure, demand before unloading is about 57.3 L. The 52 L supply falls 5.3 L short.** Scheduled withdrawals can conceal this gap. The reserve needs to cover demand through unloading, with an allowance for uncertainty. [12]

Road access returns	Water is unloaded	Scheduled: unavailable (L)	Spread out: unavailable (L)
8 hours	8 hours 6 minutes	0.0	0.0
10 hours	10 hours 6 minutes	0.0	5.3
12 hours	12 hours 6 minutes	26.0	19.5

Table 3. Same 39 people, 52 L on hand and 156 L daily need. Times are elapsed since the outage. Spread-out values use exact demand; simulations differ by less than 0.12 L (Appendix B). [12]

06 / continued

Findings

Internet equipment needed more battery energy

A **watt (W)** measures how much power equipment uses. A **watt-hour (Wh)** measures energy: one watt used for one hour is one watt-hour. A battery's rating describes stored energy before the losses allowed for in this model.

The chart shows the calculated battery rating for each equipment group operating continuously for 24 hours. The internet equipment draws substantially more power than the radio equipment in this model. These calculations exclude additional energy for sending messages. [7, 10]

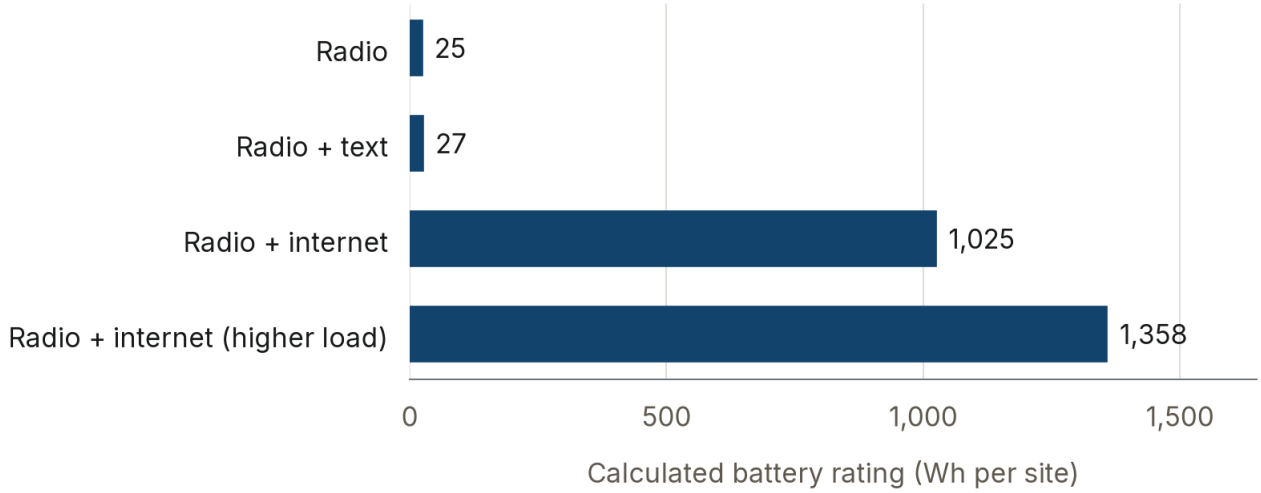


Figure 3. Calculated battery ratings for one day of continuous operation. Per site, using 80% of rated battery energy and losing 10% of that energy before it reaches equipment. Internet cases add a device using 30 W or 40 W to the radio. Values are rounded; exact inputs and the equation are in Appendix B. [7, 10]

The smaller battery could not sustain internet for 24 hours

Battery rating at each site	Outcome in the model
512 Wh	Could not sustain either tested internet setup for 24 hours.
1,600 Wh	Sustained the tested 40 W internet device and radio for 24 hours, including the modeled messages.

All three sites receive the same battery rating. Radio and internet equipment share a battery. [10]

Internet service adds a substantial battery requirement under the tested loads. Its value depends on the shelter's communications tasks. The eight-message comparison does not measure services such as online registration, maps or large-file transfers.

These quantities cover communications equipment only. Lighting, refrigeration, medical equipment and other shelter loads would require additional power. The study does not compare generators, scheduled shutdowns or separate radio batteries.

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Conclusions

The study identifies three linked planning requirements: early supply requests, stored water through delivery delays, and sufficient communications power. The comparisons show how each affects modeled shelter support. [10, 12]

Request the expected water need before stock runs out

For the main 39-person scenario, requesting water at the start removed a 78 L shortage and reduced driving from 238.4 km to 67.8 km. That result depended on a usable delivery route. It supports estimating demand and requesting resupply before the current supply is exhausted. [10]

Keep enough water until unloading is complete

During eight-hour isolation, an early request still left 32.5 L unavailable when the shelter started with 19.5 L. Starting with 52 L removed that shortage under scheduled consumption. Water already on site sustained service while the vehicle waited for access. [10]

The same 52 L covered the eight-hour test with water use spread through the day, but fell 5.3 L short during a ten-hour closure and 19.5 L short during a twelve-hour closure. **52 L is a result for these conditions, not a general shelter reserve.** Consumption and the wait through unloading determine the requirement. [12]

Match backup power to the communications tasks

The 512 Wh battery could not sustain either tested internet setup for 24 hours. The 1,600 Wh battery sustained the tested higher-load internet equipment and radio. Battery selection therefore requires the actual equipment load and required operating time. [10]

Why these findings matter

Prompt confirmation does not ensure that supplies arrive before they are needed. Shelter planning must account for the time from a request to completed unloading and the energy needed to maintain coordination. The study provides a way to test these dependencies together before selecting water and battery quantities.

The next step for local use is to check attendance and consumption, likely delivery delays, available stock and transport, and equipment loads. The separate limitations page identifies what this study has not established.

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Limitations

The findings apply to the modeled conditions. Actual facility suitability, road access and equipment performance require local verification before these quantities can support an operational plan.

Area requiring verification	Effect on the findings
People and water use	Actual attendance and consumption may differ. The 156 L example covers drinking water only; washing, food preparation and other uses add demand.
Facilities and access	Modern shelter activation and usable capacity are unverified. Map connections do not verify entrances, legal turns or a passable route after damage.
Supplies and delivery	Confirm who can order and dispatch, available stock, crews and vehicles, and time to load, travel and unload. The model assumes these resources exist.
Communications and power	Measure equipment loads and usable battery energy. Verify links at the actual sites and include other shelter power needs. Terrain checks do not prove radio service.

Model simplifications

The model assumes known road-reopening times; actual dispatch would involve greater uncertainty. Vehicles can wait to enter a road, but queues do not back up onto preceding road sections. These simplifications can affect delivery times.

Water is consumed according to two chosen patterns. Actual timing could require a different reserve. These quantities have not been checked against measured attendance, consumption or delivery delays.

Radio and internet availability are assumed. The workload contains only eight common short messages, plus supply requests. It cannot establish which communications technology best supports all shelter services.

The comparison with 2002 supports the kinds of disruption studied. It does not show that these policies would have improved the actual response by the simulated amounts. Some original cases use a smaller population and other settings; Appendix A preserves those comparisons. [1, 2, 9, 10]

Use the findings to frame a local planning exercise. The results identify questions about stock, delivery and power; they are not a facility activation plan or an equipment purchase specification.

APPENDIX A

Full run matrix and geographic method

Original group	Cases	Design
Main comparison	96	2 road-rounding choices x 2 population allocations x 4 stock/request policies x 2 battery sizes x 3 communications arrangements.
Added challenges	12	Eight-hour isolation, half road speeds or a 40 W terminal; each with advance/bridge and radio/radio plus internet.
Random message checks	15	Bridge policy: 5 shared random seeds x 3 arrangements. A seed makes a random sequence repeatable.

The main design uses 29/39 people, 0.1/1 metre (m) road rounding, 512/1,600 Wh per site, and radio, radio plus text, or radio plus internet. The main report selects 39 people, 1 m rounding and seed 17. Its water tables use radio and 1,600 Wh per site; Table 2 also reports the matching internet result. Challenges use 39 people and 1,600 Wh; random checks use 52 L and 1,600 Wh. [10]

Policy name in saved data	Starting water	Request rule
Reactive	0.5 L/person	Request after a consumption shortage.
Advance	0.5 L/person	Request the remaining daily need at the start.
Bridge	Exactly 4/3 L/person	Start with two withdrawals in stock; request the rest at the start.
Full-day stock	4 L/person	All modeled daily water is already at the shelter.

For 39 people, full-day stock is 156 L and avoids post-event water travel in the model. Pre-event positioning effort is outside all comparisons. For 29 people, bridge/full-day stock is 38.7/116 L. Of the 96 main cases, 60 meet all targets; all 15 random checks do so. These fractions describe chosen cases, not the probability of disaster success. [10]

Added timing design: 24 cases = 2 policies (advance/bridge) x 2 schedules (withdrawals/spread out) x 3 closures (8/10/12 hours) x 2 arrangements (radio/radio plus internet). Fixed: 39 people, 1 m rounding, 1,600 Wh and seed 17. Three bridge/radio cases repeat at a finer time interval. [12]

Geography, population and history

Retained roads join at shared points after rounding. Plotted segments match source geometry within 0.71 m; site connectors are assumed. Grid distances start at the southwest corner. Legal movements remain unverified. [3, 4, 9]

American Community Survey (ACS) 2020-2024 household estimates are spread by area or building outlines. Chosen rates of 20% displaced and 10% seeking this shelter give 29/39 arrivals. Five corridor variants give about 15-72 arrivals. Assumed capacity is 60; 72 arrivals would leave 12 needing shelter elsewhere. [5, 9]

The 28 April 2002 tornado caused F4 damage (category 4 on the original Fujita scale) across Routes 301 and 6. Its maximum reported width, 650 yards (about 594 m), is applied uniformly to the approximate corridor; position checks shift it 500 m either way. Historical command used the County Office Building parking lot and later Town Hall. A report counted 31 overnight guests; this does not calibrate modern demand. [1, 2, 11]

APPENDIX B

Model settings and calculations

Setting	Value and interpretation
Transport and traffic	40 kilometres/hour (km/h) on roads; 5 km/h on site connections. Road-entry capacity 600 vehicles/hour; one bottleneck receives 180 other vehicles/hour for six hours. Van cargo limits: 500 kilograms (kg), 3 cubic metres; 80 L starting fuel.
Radio and terrain	Antennas 10 m above ground; 696 ground-elevation samples from a March 2023 survey. Buildings, trees and interference are not modeled as measured radio losses.
Messages	Each link assumes 95% success per attempt for a message and its confirmation separately; at most three attempts. Eight common messages: urgent and routine at hours 2, 10, 18 and 23. Supply requests are extra.
Service time	Message/confirmation per link: radio 20/5 seconds, text 3/1, internet 1/1. Operator processing 30 seconds; retries wait 30 seconds. Text uses sequential links; full mesh-network behavior, where devices relay for each other, is omitted.
Internet availability	Each site has an assumed connection independent of failed local backhaul (links to the wider telephone/internet system). The terminal draws 30 W centrally or 40 W in the load challenge.

Battery calculation

Rated energy (Wh) = continuous power (W) x 24 hours / (0.80 x 0.90). The model uses 80% of rated capacity and delivers 90% of that energy to equipment. Radio, radio plus text, and the two internet profiles draw 0.74, 0.80, 30.74 and 40.74 W. Their calculated ratings are 24.7, 26.7, 1,024.7 and 1,358.0 Wh. These are continuous-load lower bounds; message energy is additional. Rated batteries of 512/1,600 Wh deliver 368.6/1,152 Wh after the chosen losses. [7, 10]

Consumption spread through the day

The added pattern preserves 156 L while weighting use by arrivals: 19 people are present for 23 hours and 20 for 21 hours, totaling 857 person-hours. For unloading more than three hours after the outage, let t be elapsed hours. Cumulative demand is 156 x [19 x (t - 1) + 20 x (t - 3)] / 857. This normalization is a chosen pattern, not a measured hourly rate. [12]

At unloading after 8/10/12-hour closures, exact demand is 43.107/57.306/71.504 L. Subtracting 52 L gives shortfalls of 0/5.306/19.504 L. Table 3 uses these exact values rounded to one decimal. One-minute simulation results are 0/5.203/19.401 L; 15-second results are 0/5.292/19.490 L. Differences are below one interval's demand: 0.1184/0.0296 L respectively. [12]

Checks and source trail

The prior complete review reconciled all 150 selected cases, passed 48 software tests and reproduced eight saved simulations. These check the declared implementation; they do not establish field accuracy. The current revision changes presentation only. Original and added run manifests, selected inputs and calculations remain in the project records. [9, 10, 12]

09

Sources and references

Modern analytical inputs retain the 8 October 2026 cutoff. Historical sources were rechecked on 9 October for this comparison; their observation dates remain 2002. The timing addition uses chosen assumptions and no new modern observations. Report revision: 10 October 2026.

[1] National Weather Service: La Plata tornado, 28 April 2002. April 2002 Storm Data, printed pp. 3 and 5: rating, maximum width and downtown crossing. Track-map geometry remains approximate.
April 2002 Storm Data | Historical tornado track map

[2] Town of La Plata: After the Storm Passed By. Retrospective, printed pp. 11-15. Source for the historical comparison; present-day status remains unverified.
Town historical account

[3] Maryland Department of Transportation, State Highway Administration: road network. Public road geometry retained on 8 October 2026; does not verify legal turns, lane access or disaster travel speed.
Road network service

[4] Maryland geospatial services: address locations and building outlines. Proposed site locations and building outlines; address matches do not establish entrances or emergency designations. Building-data dates vary.
Address location service | Building footprint service

[5] United States Census Bureau: 2026 Planning Database. ACS 2020-2024 household variables. Displacement, participation and spatial allocation are study choices.
Download population planning database

[6] Maryland geospatial services: Charles County ground elevation. March 2023 survey in provider metadata; 696 checked path samples. Coverage remains uncalibrated.
County elevation service

[7] Starlink Mini specification. Retained 25-40 W average terminal-power reference; not evidence of local equipment or service.
Mini specification

[8] Meshtastic: radio settings. Low-rate text context; the simulation omits complete device-relay behavior.
Radio settings documentation

[9] Project source and geographic records. Input and source register (INPUT_REGISTER); Single broad gap research pass and implementation disposition (EDR-01); Geographic preparation and conditional-run verification (VER-02). These retain source origins, site and road assumptions, population estimates and corridor variations.

[10] Project plan, results and calculation checks. Requirements analysis goal and bounded readout (IAP-04); Conditional requirements verification (VER-03); run 20261009T013034365857Z. The reviewed summary (checked_summary.csv) corrects delivery-time extraction from preserved event logs; physical results are unchanged. Complete project review (VER-05) and readability revision checks (VER-06) supplement these results. Checks are in validation.json; file locations and rebuild commands are in source/SOURCE_NOTES.md beside this report.

[11] Reel and McCaffrey, The Washington Post: Close Calls, And Worse, In Storm's Path. Contemporary reporting; context only.
Contemporary account

[12] Project water-timing addition. Owner-directed IAP-04 addendum; Water timing and historical comparison verification (VER-04). The selected run and frozen inputs are identified in source/timing_selection.json. Timeline, summary and exact-demand checks are retained with that run.