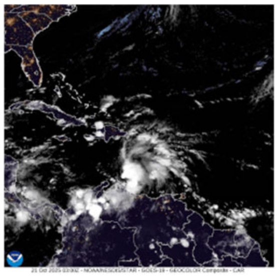
Water Treatment Project

Hurricane Melissa – October 2025

Hurricane Melissa attained Category 5 status early on October 27, with maximum sustained winds of 185 mph.

The storm made landfall near New Hope in Westmoreland Parish, Jamaica.



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Hurricane Melissa – October 2025

The storm caused catastrophic damage upon landfall in Jamaica, becoming the strongest hurricane on record to hit the island, surpassing Hurricane Gilbert in 1988.

It also produced the highest wind gust ever recorded by dropsonde data, 252 mph.

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Hurricane Melissa – October 2025

Many towns in western Jamaica were also significantly flooded as a result. In all, 102 deaths were attributed to Melissa, with estimated monetary losses in Jamaica of near US$10 billion.

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Hurricane Melissa – October 2025

About 200,000 customers, or 35% of Jamaica's homes and businesses, were left without power. The parishes of Saint Elizabeth, Westmoreland, Saint James, Trelawny, and Hanover, which received the worst of Melissa's impacts, lost all communication.

Around 150,000 structures were damaged by Melissa. The storm ripped the roofs off about 120,000 structures. Around 24,000 buildings were destroyed.

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Hurricane Melissa – October 2025

As of January 1, 2026, many areas remained without access to electricity, roads, or clean water.

In a statement, Jamaica's National Water Committee announced it still had not been able to repair water supply infrastructure.

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Hurricane Melissa – October 2025

Due to the nature of the disaster, the water treatment systems have been disrupted and will need to be repaired.

Representatives of the U.S. Army Corps of Engineers, Vicksburg District, are soliciting bids for a new water treatment system (WTS) to be constructed in Jamaica.

Each system is expected to provide up to 20 million gallons per day (MGD).

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The bid package must include:

Proposal bids must be submitted no later than **Sunday, February 22, 2026,** with company representatives on hand to present a brief **5-minute** overview of the proposed design.

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Proposal packages should be addressed to:

Lieutenant General William H. Graham, Jr.
Commanding General of the
U.S. Army Corps of Engineers
441 G St NW
Washington DC, 20314

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Schedule:

Month	Date	Event
January	27-29	Project introduction; jar test; Water System #1
February	3-5	Water System #2
	10-12	Water System #3
	17-19	Design, construct, and test Water System
	22	Project Report and Presentation Sunday evening at 6:00 p.m.

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The objective of this project is to utilize, within given constraints, a prototype WTS to design a full-scale system.

The effectiveness of the WTS will be evaluated by the yearly operational and maintenance costs.

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Each prototype WTS will be scaled-up to handle a flowrate of **20 million gallons per day** (MGD).

The effluent water must have an **average turbidity < 2 NTU**

To handle backwashing and cleaning of the WTS, the overall size of the treatment system should be increased by 20% or a safety factor SF of 1.2

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The full-scale WTS may be constructed with any combination of the following three processes:

- coagulation and flocculation basins (5 MGD)
- sedimentation tanks (each tank is 75,000 gallons)
- ~32-foot square filters (1,000 $ft.^2$ per filter)

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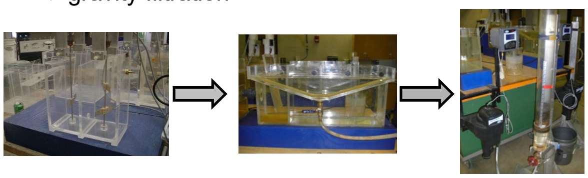
The prototype WTS will consist of three sequential processes:

- coagulation and flocculation
- sedimentation
- gravity filtration



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Each prototype WTS must meet the following criteria:

1. The filter material height may not be greater than 8 in.
2. Anthracite and/or filter sand may be used in the filter
3. The maximum filter run is 60 minutes
4. The effluent must have an average turbidity of less than 2 NTU
5. The water height above the filter material must be maintained at 6 in.

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Water Treatment Project

Coagulation and Flocculation Cost

From jar tests data you should be able to select a cost-effective dosage of ferric chloride that destabilizes the suspend solids.

The coagulation and flocculation cost of the treatment system are:

- Operation and maintenance (OM) cost including construction
- Material costs - ferric chloride

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Water Treatment Project

Coagulation and Flocculation Cost

- Operation and maintenance cost for the coagulation and flocculation system (OMCF) is dependent on the system flowrate and the cost per unit.
- A single full-scale coagulation and flocculation unit capable of treating 5 MGD has a cost of $25,000 per year
- Ferric chloride and associated chemicals cost $1 per kg

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Coagulation and Flocculation Cost

The weight of coagulant $\boldsymbol{wt_c}$ required per gallon of treated water is estimated as:

$$wt_c\left[\frac{kg}{gal}\right]=\left(\frac{\text{dosage mg}}{\text{L}}\right)\left(\frac{3.785\text{ L}}{\text{gallon}}\right)\left(\frac{\text{kg}}{10^6\text{ mg}}\right)$$

where ***dosage*** (mg/L) is a design variable in the cost model.

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Water Treatment Project

Coagulation and Flocculation Cost

The number of coagulation and flocculation units *NCF* required is:

20% Factor of Safety

$$NCF = Roundup\left[\left(\frac{\text{required flowrate (gpd)}}{5\times10^6\text{ (gpd)}}\right)\times SF\right]$$

where ***required flowrate*** (gpd) is a design parameter in the cost model.

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Water Treatment Project

Coagulation and Flocculation Cost

The number of coagulation and flocculation units required is:

$$Cost_{CF} = NCF\left(\frac{\$25{,}000}{\text{year}}\right) + \left(wt_c \frac{\text{kg}}{\text{gal}}\right)\left[\textit{required flowrate}\,(\text{gpd})\right]\left(\frac{365\text{ days}}{\text{year}}\right)\left(\frac{\$1}{\text{kg}}\right)$$

where ***required flowrate*** (gpd) is a design parameter in the cost model.

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Water Treatment Project

Sedimentation System Cost

The size of the prototype sedimentation tank can be varied - each sedimentation basin contains four individual tanks

Each prototype tank is 6 in. wide, 10 in. deep, and 6 in. long (volume = 360 in.^{3})

You may operate these tanks in any manner you wish; however, once a tank is in use it become a permanent part of your treatment system

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Water Treatment Project

Sedimentation System Cost

The full-scale sedimentation tanks will have the following characteristics:

1. The volume of each tank is 75,000 gallons
2. To provide continuous sedimentation during the year, approximately 20% of your tanks must be inoperative at any given time (this will accommodate the cleaning time)

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Water Treatment Project

Sedimentation System Cost

Step 1 - Compute the prototype sediment tank ***retention time*** t_p

$$t_P = \frac{n_t\left(\text{Volume}_{\text{tank}}\right)}{Q_S}$$

where: n_t is the number of prototype tanks
Volume$_{\text{tanks}}$ is the volume of one tank
Q_S is the flowrate in the sedimentation tanks (mL/min)

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Water Treatment Project

Sedimentation System Cost

Step 1 - Compute the prototype sediment tank ***retention time*** t_p

$$t_P = \frac{n_t\left(\text{Volume}_{\text{tank}}\right)}{Q_S}$$

where $\boldsymbol{Q_s}$ (ml/min) and $\boldsymbol{n_t}$ are design variables in the cost model.

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Sedimentation System Cost

Step 1 - Compute the prototype sediment tank ***retention time*** t_p

$$\text{Volume}_{\text{tank}} = 360\text{ in.}^3\left(\frac{\text{gallon}}{231\text{ in.}^3}\right) = 1.56\text{ gallons}$$

$$t_P = \frac{n_t\,(1.56\text{ gallons})}{\left(\textit{flowrate}\,\frac{\text{mL}}{\text{minute}}\right)\left(\frac{\text{gallon}}{3{,}785\text{ mL}}\right)}$$

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Water Treatment Project

Sedimentation System Cost

Step 2 - The full-scale ***treatment flowrate*** $\boldsymbol{Q_{ST}}$ (gpm) per sedimentation tanks is:

$$Q_{ST} = \frac{\text{tank volume (gallons)}}{t_P}$$

The full-scale sedimentation tanks are 75,000 gallons

$$Q_{ST} = \frac{75{,}000 \text{ gallons}}{t_P}$$

Water Treatment Project

Sedimentation System Cost

Step 3 - The ***effective flowrate*** $\boldsymbol{Q_{SE}}$ (gpm) in a sedimentation tank is:

$$Q_{SE} = Q_{ST}\left(\frac{\text{filter run time}}{60 \text{ minutes}}\right)$$

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Sedimentation System Cost

Step 4 - The number of full scaled sedimentation tanks, ***NS*** required to handle the daily volume is estimated as:

$$NS = Roundup\left[\left(\frac{\textit{required flowrate}\,(\text{gpd})}{Q_{SE}\,(\text{gpm})}\right)\left(\frac{\text{day}}{1{,}440\,\text{min}}\right) \times SF\right]$$

20% increase for cleaning

where ***required flowrate*** (gpd) is a design parameter in the cost model.

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Sedimentation System Cost

The operation and maintenance costs per full-scale sedimentation tank is $35,000/tank

The yearly costs per sediment tank is:

$$Cost_S = NS\left(\frac{\$35{,}000}{\text{tank}}\right)$$

Water Treatment Project

Filtration System Cost

Each WTS must meet the following criteria:

1. The filter material height may not be greater than 8 in.
2. Anthracite and/or filter sand may be used in the filter
3. The maximum filter run is 60 minutes
4. The effluent must have an average turbidity of less than 2 NTU
5. The water height above the filter material must be maintained at 6 in.

Water Treatment Project

Filtration System Cost

The full-scale filters will have the following characteristics:

1. Each filter is 31 ft. by 31 ft. in area (~1,000 ft.^{2})
2. A 20% factor of safety (this will accommodate the backwashing time)
3. The filter media will be replaced every five years

Water Treatment Project

Filtration System Cost

If either of the following criteria are violated:

1. the pressure head exceeds above 6 in.
2. The average turbidity > 2 NTU

The time when the filter exceeded these criteria is the filter run time (less than 60 minutes).

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Water Treatment Project

Filtration System Cost

Step 1 - Convert the average flowrate through the prototype filter (the 3.5 in. diameter prototype filter has an area of 0.0668 ft.^{2}) into a prototype ***filter loading rate Q_F*** (gpm/ft.^{2}).

$$Q_F = \left(flowrate \frac{\text{mL}}{\text{minute}}\right)\left(\frac{\text{gallon}}{3{,}785\text{ mL}}\right)\left(\frac{1}{0.0668\text{ ft.}^2}\right)$$

where ***flowrate*** (ml/min) is a design variable in the cost model.

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Water Treatment Project

Filtration System Cost

Step 2 - The full-scale ***treatment flowrate Q_{FT}*** is:

$$Q_{FT} = Q_F\left(\text{gpm}/\text{ft.}^2\right)\times\text{filter area}\left(\text{ft.}^2\right)$$

Remember that the full-scale filters are 1,000 ft.^{2}

$$Q_{FT} = Q_F\left(\text{gpm}/\text{ft}^2\right)\times 1{,}000\text{ ft.}^2$$

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Water Treatment Project

Filtration System Cost

Step 3 - Considering that each filter is inoperable during backwashing, the ***effective flowrate Q_{FE}*** is:

$$Q_{FE} = Q_{FT}\left(\frac{\text{filter run time}}{60\text{ minutes}}\right)$$

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Water Treatment Project

Filtration System Cost

Step 4 - The number of full-scaled filters ***NF*** required to handle the daily volume is estimated as:

$$NF = Roundup\left[\left(\frac{required\ volume(\text{gpd})}{Q_{FE}(\text{gpm})}\right)\left(\frac{\text{day}}{1{,}440\text{min}}\right)\times SF\right]$$

20% increase for backwashing

where ***required flowrate*** (gpd) is a design parameter in the cost model.

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Water Treatment Project

Filtration System Cost

The total yearly costs to operate and maintain a full-scale filter system is separated into two components:

The operation and maintenance (OM_F) costs per filter - $45,000/filter

The costs of filter media:
anthracite - $9.50/ft.^{3}
filter sand - $5.90/ft.^{3}

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Water Treatment Project

Filtration System Cost

The yearly cost per filter is:

$$Cost_F = NF\left(\frac{\$45,000}{\text{filter}}\right)$$

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Water Treatment Project

Filtration System Cost

The yearly cost for anthracite is:

$$Cost_{FM_A} = \text{thickness}(\text{in.})\left(\frac{\$9.50}{\text{ft.}^3}\right)\left(\frac{\text{ft}}{12\text{ in.}}\right)\left(1,000\text{ ft.}^2\right)\left(\frac{NF}{5}\right)$$

Material replaced every five years

The yearly cost for filter sand is:

$$Cost_{FM_S} = \text{thickness}(\text{in.})\left(\frac{\$5.90}{\text{ft}^3}\right)\left(\frac{\text{ft.}}{12\text{ in.}}\right)\left(1,000\text{ ft.}^2\right)\left(\frac{NF}{5}\right)$$

$$Cost_{FM} = Cost_{FM_A} + Cost_{FM_S}$$

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Total Treatment System Cost

$$\text{Total Cost} = Cost_{CF}$$ Coagulation

$$+ Cost_S$$ Sedimentation

$$+ Cost_F$$ Filtration

$$+ Cost_{FM}$$ Filtration Media

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Any questions?

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