Episode Book

EPISODE #5888

Where Does the Rain Actually Go?

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SYNOPSIS

Rain on a city street is a plumbing problem arriving all at once. This episode digs into the hidden engineering of municipal drainage: the difference between storm sewers and sanitary sewers, why combined systems were a deliberate Victorian design choice rather than a mistake, and how engineers decide how much rain a pipe has to swallow. Then it climbs into the megaprojects — Tokyo's G-Cans cathedral of concrete silos and pillars, London's Tideway Tunnel — and asks the harder question underneath all of it: what happens when the storm is bigger than the design, and whether the discipline is shifting from getting water out of the city fast to keeping it in the city on purpose.

TRANSCRIPT



Corn

Rain on a city street sounds like weather. It's actually a plumbing problem arriving all at once.



Herman

And it's a plumbing problem most people have never once thought about, which is exactly why Daniel asked. He's in Jerusalem, he's watched the rain come down, and he wants to know the embarrassingly basic thing: where does all of it actually go?



Corn

He wants the hidden engineering. How municipal drainage is designed, how engineers decide how much rain a system has to swallow, what the difference is between a storm drain and a sanitary sewer, and why those two things being separate is a relatively modern idea.



Herman

And then the cathedrals. Tokyo's underground discharge channel, London's Tideway Tunnel. The megaprojects.



Corn

Right, and then the part I actually care about. What happens when the storm is bigger than the design. And whether the whole discipline is shifting from getting water out of the city fast to keeping it in the city on purpose.



Herman

Invisible until it fails. That's the whole topic in four words.



Corn

So let's make it visible.



Herman

Start with the volume, because the volume is what makes this an engineering problem instead of a landscaping problem. An inch of rain on an acre of impermeable surface is about twenty-seven thousand gallons. A city block of rooftops and asphalt during a real storm is dumping water at a rate no natural catchment would.



Corn

And the natural catchment would have absorbed most of it. That's the thing the city paved over.



Herman

Soil takes it, plants drink it, the rest percolates down. Pavement doesn't do any of that. So the city has to do artificially what the ground used to do for free, and it has to do it in a few hours instead of a few days.



Corn

Which means three possible arrangements of pipes, and everything else in this episode builds on which one a city has.



Herman

Give me the three.



Corn

One. Separate sanitary. One network carries wastewater from homes and businesses to a treatment plant. A completely separate network, the municipal separate storm sewer system, collects the rain off driveways, parking lots and streets and dumps it straight into a local waterway. Treated water one way, untreated rain the other.



Herman

Which sounds alarming until you remember rain falling on a street isn't sewage. It's just water that picked up some oil and dog hair on the way.



Corn

Two. Combined. Wastewater and stormwater share the same pipes. Dry weather, everything goes to treatment. Wet weather, the flow overwhelms the system, and permitted outfalls act as relief points, discharging untreated or partially treated stormwater and wastewater straight into the river. Those are combined sewer overflows.



Herman

And three is just the first one done properly with the storm network built out. Most US communities today have separate sanitary systems. But roughly seven hundred still run combined, and those seven hundred are the ones with the consent decrees and the headlines.



Corn

The interesting part is that combined systems weren't a mistake. They were the design. One pipe, everything in it, cheapest possible thing to build under a Victorian street.



Herman

Bazalgette's London system was exactly that. Eighteen fifty-nine to eighteen seventy-five, built for a city of four million people. And it was a triumph. It ended the cholera. It just didn't anticipate the city getting to nine million and the rain getting weirder.



Corn

So the system that saved London is now the system drowning it.



Herman

Which is where design storms come in, and this is the part Daniel's actually asking about. How does an engineer decide how much rain the pipe has to handle? He doesn't design for all of it. He designs for a storm with a return period.



Corn

Define that carefully, because everyone gets it wrong.



Herman

Return period is the average length of time between occurrences where the value, flood magnitude or flow rate, is equaled or exceeded. Average. So a hundred-year storm isn't a storm that happens once a century. It's a storm with a one percent chance of happening in any given year. Which means you can get two in a decade and nobody's lying to you.



Corn

And you can go forty years without one and everyone forgets the pipe exists.



Herman

Right. Engineers pull historical precipitation records, build what are called intensity-duration-frequency curves, and read off how hard it rains for how long at what frequency. Those curves are described as one of the most important tools for design, operation and maintenance of sewers, stormwater ponds, curbs, gutters and catch basins. Everything from the grate at the corner to the culvert under the highway comes off the same family of curves.



Corn

And the federal reference for the highway version is HEC-22. Fourth edition. It's the manual everybody cites and nobody reads for pleasure.



Herman

In the States you also have NOAA Atlas 14, which gives you the point precipitation frequency estimates for your specific location. So an engineer in Phoenix and an engineer in Miami are working from completely different numbers.



Corn

Good. Now the part where the risk gets priced in, because this is the sentence that explains the entire episode.



Herman

The Iowa DNR stormwater manual says it plainly. For economic reasons, some risk of failure is allowed in selection of the design event.



Corn

Some risk of failure is allowed. That's the design philosophy. They're not pretending. They're telling you the pipe is sized to fail occasionally on purpose, because sizing it not to fail would cost more than the flooding.



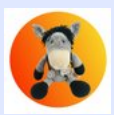
Herman

And in practice US municipalities run a two-tier system. A minor storm, often the five-year event, for ordinary drainage structures. A major storm, the hundred-year event, for vital or critical structures. Hospitals, substations, the things you cannot have underwater.



Corn

So a city handles routine rain perfectly and then floods during an extreme event, and people say the drainage failed. The drainage didn't fail. The drainage did exactly what the spreadsheet told it to.



Herman

It's the thing I keep circling back to with infrastructure. We built it to a standard, the standard was a number somebody chose, and the number was a budget decision dressed up as a hydrology decision.



Corn

Now the part that actually worries the engineers. Stationarity.



Herman

IDF curves assume the same underlying processes will govern future rainfall patterns. That's the assumption. The past is a reliable guide to the future. And climate change is exactly the thing that breaks it. The old records describe a climate that no longer exists.



Corn

So you're sizing a pipe for a hundred-year storm using a hundred years of data from a different century.



Herman

And there's work suggesting a fix. Adding safety factors of roughly one point four to one point seven on top of standard stormwater pipe design guidance produces robust performance under deep climate uncertainty. You don't need to know how much worse it gets. You just build in the margin.



Corn

Does anyone actually do that yet?



Herman

Not systematically. That's the gap between the paper and the permit application. A safety factor of one point five on a storm sewer means bigger pipes, deeper trenches, more money, and a council meeting where somebody asks why we're spending extra on a storm that maybe won't happen.



Corn

So the honest answer to Daniel's first question is that we know how to do it and we mostly don't.



Herman

That's a bit harsh. We do it to a standard. The question is whether the standard still means anything.



Corn

Let me ask you something. If you were the engineer signing off, and you had the stationarity problem in front of you, would you add the margin?



Herman

I would, and I'd get argued down, and I'd probably lose. Which is the actual job. The engineer who adds the margin isn't the hero of the story, he's the guy who came in over budget.



Corn

And then it floods and he's the guy who was right and everyone still remembers the budget.



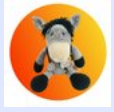
Herman

That's the whole incentive structure of drainage in one sentence.



Corn

So now let's look at what happens when a city decides the standard isn't enough.



Herman

Tokyo's Metropolitan Area Outer Underground Discharge Channel. G-Cans. The world's largest underground floodwater diversion facility, out in Kasukabe and Showa, on the northern edge of the city.



Corn

Describe the shape of it, because the numbers are the point.



Herman

Five concrete containment silos. Each one about sixty-five metres tall and thirty-two metres in diameter. Connected by roughly six point four kilometres of tunnel running fifty metres below ground.



Corn

Fifty metres is deep enough that you could put a fifteen-storey building in the hole and still have room for the building next door.



Herman

And then the famous chamber. The pressure-adjusting water tank. A hundred and seventy-seven metres long, seventy-eight wide, twenty-five point four high. Supported by fifty-nine pillars, each around five hundred tonnes.



Corn

It looks like a cathedral. People call it the Underground Temple and they're not being cute about it.



Herman

And the pillars aren't decoration. There are deliberately so many of them partly because they act as ballast against groundwater uplift. The tank would float without the weight. And the ends are curved so the water flows smoothly around them instead of hammering the concrete.



Corn

Seventy-eight pumps. Fourteen thousand horsepower of turbines. Two hundred tonnes of water a second into the Edo River.



Herman

A tonne of water is a cubic metre, so two hundred cubic metres a second. That's a small river, arriving on demand, going the other way.



Corn

And the design standard?



Herman

Designed to withstand a once-in-two-hundred-year flood. Construction started in nineteen ninety-two. Completed early two thousand six by most accounts, though one source says two thousand nine and roughly two billion dollars, so flag the discrepancy rather than pick a winner.



Corn

What happens to it in the dry season?



Herman

It sits empty. And you can visit it. It's a tourist attraction. The flood defence is also a day out.



Corn

Which is the most Japanese thing in this entire episode. The infrastructure is on the gift shop schedule.



Herman

And here's the detail I find humbling. The inspection is done by hand. Radio signals don't penetrate fifty metres of ground, so crews pump air into the tunnels and walk them, doing visual checks and tapping the concrete with hammers. Every year.



Corn

No drones, no telemetry. A man with a hammer in the dark.



Herman

You can't automate a look.



Corn

So the most advanced flood facility on earth is maintained by hand because the physics won't cooperate.



Herman

Then London, which is the same idea in a different hole. Tideway. Twenty-five kilometres of deep-level combined sewer from Acton in the west to Abbey Mills in the east, then joining the six point nine kilometre Lee Tunnel to Beckton.



Corn

Diameter?



Herman

Seven point two metres internal. Thirty metres deep at the western end, seventy at the eastern end.



Corn

So the pipe is wide enough to drive a van down and deep enough to lose one.



Herman

And it was built because the Bazalgette system hit its ceiling. By twenty eleven, the overflows were happening more than once a week. As little as two millimetres of rain could trigger a discharge. And the mean was about thirty-nine million tonnes of storm sewage going into the Thames every year.



Corn

Two millimetres. That's a light drizzle.



Herman

That's the system admitting it's full. Tideway intercepts thirty-four of the most polluting overflows, and the expectation is that discharges fall from an average of about sixty a year to fewer than five, with the residual overflow down to roughly two point six million cubic metres a year.



Corn

Cost?



Herman

Final estimate around five billion pounds as of twenty twenty-four. It adds twenty to twenty-five pounds a year to the average wastewater bill.



Corn

Twenty-five pounds a year to not have sewage in the river. That's the deal of the century and people still complained.



Herman

Construction began twenty sixteen. First sewage flowed in September twenty twenty-four. Fully connected on the fourteenth of February twenty twenty-five. Operational that February. Officially opened on the seventh of May twenty twenty-five by King Charles. And Tideway's twenty twenty-five, twenty-six annual report says the tunnel has intercepted over



Herman (continued)

twenty million tonnes of storm sewage.



Corn

Since twenty twenty-four. That's more than half the annual problem already.



Herman

It's already stopping half a million tonnes from entering the Thames in the early running. That number and the twenty million are measuring different windows, but either way it's working.



Corn

Now go back to the critique, because this is where the episode gets interesting.



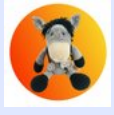
Herman

There's a line from the opponents that's been quoted everywhere. The tunnel is an unsustainable nineteenth-century solution to a twenty-first-century problem. Their argument is that the rainwater from roads should go directly to canals and rivers, and that landowners should be installing soakaways so the water never enters the sewer at all.



Corn

Which is a completely serious engineering position and also a completely serious political one.



Herman

And it's not wrong on the physics. If the rain doesn't get into the combined pipe, the combined pipe doesn't overflow. It's just that doing that across a city of nine million is a coordination problem of a different scale to digging one tunnel.



Corn

You can build one tunnel with one contractor and one budget. You cannot get nine million people to retrofit their driveways.



Herman

That's the honest trade. Centralised grey infrastructure is expensive and it works. Distributed green infrastructure is cheaper per unit and it requires every property to participate.



Corn

So London picked the thing that could actually be finished.



Herman

And the same debate is playing out everywhere. The Gulf region is looking at permeable bricks and technology to reduce flooding, reported just a couple of weeks ago. China's sponge city program is the same idea at national scale. And there's a recent preprint proposing LLM-based tooling to inspect and maintain green stormwater infrastructure. Permeable pavement, rain gardens, bioretention.



Corn

An agent that goes and checks the rain garden.



Herman

Inspecting and scheduling maintenance. Which is the part of green infrastructure nobody budgets for.



Corn

Of course it isn't. A rain garden looks like a flower bed. Nobody thinks a flower bed needs a maintenance contract until it clogs and stops draining and the water it was supposed to absorb ends up in somebody's basement.



Herman

That's the actual argument against green infrastructure, by the way. Not that it doesn't work. That it works exactly as long as somebody keeps maintaining it, and distributed systems have a thousand owners instead of one.



Corn

Now answer the question Daniel actually asked. What happens when the storm exceeds the design?



Herman

Depends which system you have. Combined, you get an overflow. The relief point discharges, and the river takes the hit. Separate, you don't get the sewage problem, but you can still flood, because the inlets get blocked with leaves, or the system was designed to an older standard, or the storm simply exceeds what the pipe can carry and the water backs up into the street.



Corn

And the reason cities flood despite extensive drainage is that the drainage was never designed to prevent all flooding. It was designed to a return period. Some risk of failure is allowed, for economic reasons. That sentence from the Iowa manual is the answer to Daniel's whole question about limits.



Herman

It's a risk tolerance, not a guarantee. The hundred-year storm can happen twice in a decade. The five-year pipe gets a five-year storm and does fine, and then gets a fifty-year storm and the street becomes a river.



Corn

And a hundred-year pipe is not a hundred-year guarantee.



Herman

Nobody sells guarantees. They sell design events.



Corn

Give me the difference between an overflow and a spill, because those get merged in coverage and they shouldn't be.



Herman

A combined sewer overflow is a designed relief point. The system is working as permitted, discharging partially treated stormwater and wastewater. An SSO, a sanitary sewer overflow, is untreated sewage released from a sanitary system because a pipe broke, equipment failed, or it got overloaded. That's not a design feature. That's a failure.



Corn

One is the system breathing. The other is the system bleeding.



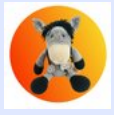
Herman

And CSOs are still a major water pollution and public health concern for about seven hundred communities in the United States. Bacteria, debris, beach closures, shellfish bed closures, algae, oxygen depletion.



Corn

The seven hundred are running systems that were state of the art in eighteen eighty.



Herman

Retrofitting them to separate is a century of digging.



Corn

Take your pick. The megaproject is the answer cities keep choosing because it's the one you can actually finish.



Herman

Tokyo went underground with silos and pumps. London went underground with a tunnel. Both are the same move. Give the water somewhere to go that isn't the street.



Corn

Both are sized to a return period they will eventually exceed.



Herman

Which is the honest end of the discussion. There is no complete solution. There's a number, a budget, and a margin somebody did or didn't add.



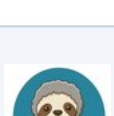
Corn

Herman, before we get to the end of this, you spent twenty minutes telling me about IDF curves. What does one of those curves actually look like on a screen?



Herman

It's a family of lines. Duration on one axis, intensity on the other, and each line is a different return period. You read across to the duration of your storm and down to find the intensity you have to design for. Two-year, five-year, ten, twenty-five, fifty, hundred. Stacked like contour lines on a map.



Corn

The engineer picks a line, and the line is a political decision.



Herman

The line is a political decision wearing a lab coat.



Corn

There's the sentence.



Hilbert

He's right, and I'll tell you how that one ends because I've watched it end.



Hilbert

Nineteen ninety-three, I was doing drainage for a county on the Illinois side, outside St. Louis. Not the storm sewers, the county's own. The maintenance yard, the impound lot, the animal shelter, the two buildings they used for records. Eleven acres of asphalt and roof. And the summer of ninety-three, the river came up, and the flood went through the yard the way it goes through a yard, and then it went down, and then a month later it rained four inches in two hours and it flooded again from the sky.



Herman

The Great Flood of ninety-three. That was the same summer.



Hilbert

It was. So the county engineer calls me in because the board wants the yard to stop flooding. And I go out with the surveyor and we shoot the grades, and I run the numbers, and the number I need is a five-year event for the yard and a hundred-year for the records building because the records building has the deeds in it.



Corn

That was who's decision?



Hilbert

The board's. Not mine. I gave them three options. Five-year everywhere, which floods every few years and costs almost nothing. Twenty-five-year everywhere, which floods once in a career and costs about four hundred thousand. Or hundred-year on the whole eleven acres.



Corn

Which they didn't take.



Hilbert

Nobody takes the third one. The board sat there with the numbers in front of them and the chairman, a man named Dale Fenwick, said, four hundred thousand dollars to keep a parking lot dry. And he said it like a man doing arithmetic, which he was.



Herman

Which did they take?



Hilbert

They took the cheapest one and put the rest in a new roof for the shelter. Eleven inches on the yard, five on the building. And I went home and thought about it and decided they were probably right. That's the part I don't say much. They were probably right.



Corn

So what happened?



Hilbert

Nothing, for nine years. And in the spring of two thousand two, we got five point six inches in about three hours, which is bigger than the five-year, and the yard went under eighteen inches and took out the impound lot and every vehicle in it. Six hundred thousand dollars of towed cars, in water, in a lot with no insurance, because the lot was designed to a five-year storm and the storm was a twenty-five.



Herman

The repair cost more than the upgrade would have.



Hilbert

It cost more than the roof. That's the sentence. And the board met and approved the drainage work, all of it, in one meeting, no discussion. Two years of arguing to save four hundred thousand, and then forty minutes to spend six hundred.



Corn

Because the flood made the argument for you.



Hilbert

The flood makes the argument every time. That's the only way it ever gets made. And you want to know the piece that still bothers me? The five point six inches was in the IDF curve the whole time. It was in the book in nineteen ninety-three. It wasn't a surprise to anybody who read the chart. It was a surprise to the board.



Herman

Because a return period is a probability and a flood is an event.



Hilbert

Yeah. And a chart is not a flood. Hold on, Corn, your level's drifting, I'm pulling you down two.



Corn

I'm fine.



Hilbert

You're not. You were fine when you said the line is a political decision wearing a lab coat. Say something that quiet again and I'll leave it alone. Anyway. Where was I. The vehicles. The adjuster came out, and he's standing in eighteen inches of water looking at a tow lot, and he says to me, this whole thing would be funny if it wasn't my job.



Herman

He wasn't wrong.



Hilbert

He was not. And two years later they built the lot up and put a hundred-year pipe under it, and Fenwick was still on the board, and he voted for it, and he said the same thing he said in ninety-three. Four hundred thousand dollars to keep a parking lot dry. Except this time he said it and then voted yes. I remember that. That's all.



Corn

The margin gets added after the flood, never before it.



Hilbert

That's what I said.



Herman

They never add it back down afterwards, either.



Hilbert

No. Nobody takes a pipe out.



Corn

The whole episode comes down to when exactly a city decides to buy insurance.



Herman

The answer is usually after the loss.



Corn

Which is the least gratifying possible conclusion and also the truest one.



Herman

Here's what I keep thinking about, though. The margin is cheap. A one point five safety factor on a storm sewer is not a hundred-year project. It's a slightly bigger pipe in a trench you were already digging.



Corn

And yet.



Herman

Yet it doesn't get written into the permit, because the permit is a minimum and the minimum is a budget.



Corn

The open question is whether the standards ever move on their own. Whether the safety factors become standard practice while the climate is still shifting under the curves, or whether every city waits for its own five point six inches and learns the same lesson in water.



Herman

The curves assume the future looks like the past. It doesn't. And every council on earth is going to get that lesson, one at a time, at the cost of whatever is standing in the low part of the yard.



Corn

Which leads us back to the thing that started this. Invisible until it fails. The pipe under the street is doing more for a city than anything above it, and nobody thinks about it until the day they can't drive through the intersection.



Herman

That's the episode. Thanks to Hilbert Flumingtop, who also runs the desk and just pulled my brother's level down mid-sentence.



Corn

He was right about the level.



Herman

He usually is. For more along these lines, there's episode twenty-five seventy-six, The Centimeter-Level Challenge of Burying City Power; episode twenty, Architectural AI; and episode fourteen oh eight, Israel Wartime Readiness Field Guide. This has been My Weird Prompts.



Corn

The human-AI collaboration podcast.



Herman

If you want more of this, everything lives at my weird prompts dot com. And if you've got a question about something nobody else has bothered to ask, send us your own prompt on Telegram at t dot me slash MWP listener bot.



Corn

We'll be back soon.

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