Artful Rainwater Design: Lessons Learned Over Time

Eliza Pennypacker and Stuart Echols

ABSTRACT Artful rainwater design (ARD) emerged in the United States in the 1990s as a creative way to manage rainfall typical of temperate climates. ARD is performative and *revelatory*: it shows viewers what the rain is doing—where it is moving from and where it is going on a site—and helps the public understand rain as a resource, not a waste product. Indeed, the defining characteristic of ARD is its revelation of rain's beneficial impact, or its "rain message." If ARD is to become an accepted, revelatory norm in rain management, designers, managers, and owners of ARDs must ensure that the rain message in every installation remains legible *for the long term*. This study addresses a simple question: Can we derive useful considerations to guide designers toward long-term "rain message legibility" in future ARDs? To answer this question, we returned to 20 ARDs presented as noteworthy case studies in our 2015 book on ARD. All of these sites are now 10–20 years old. Are their rain messages still legible? The answer is varied, providing many useful insights. This study combined updated site observations of the projects with interviews of case study ARD designers and managers. The results are one set of observation-derived themes and another of interview-derived themes, with the intersection of those themes producing a body of useful considerations for future ARD design.

KEYWORDS Green stormwater infrastructure, stormwater management, low-impact development, Sustainable urban drainage system, revelatory design

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BACKGROUND

Artful rainwater design (ARD) began to appear in the 1990s as a creative way to manage rain with multiple benefits: ARD can provide on-site mitigation of runoff quantity and/or quality for small rains typical of temperate climates. It is also aesthetically pleasing, designed to be perceived as a landscape amenity. But ARD goes beyond the attractive rain garden or wet pond by revealing what the rain is doing. In other words, ARD is not only *per*formative, it is *in*formative, displaying where the rainwater is moving from (rooftop, paved surface, etc.) and where it is going (watering plants, flowing into a cistern for future use, flowing into a stream, etc.). Sometimes it goes further to tell a larger story about rain's important impact on environmental systems (Figure 1). The key is that ARD always seeks to tell an informative story about the rain. It is a creative way to show the public that rain matters and an exciting way for the design of a landscape to strive to change public perception of rain so that they see it not as a waste product but as a resource.

ARD is linked to the emergence of "ecological design" in landscape architecture, advocated since McHarg's *Design with Nature* (1969) and continuing through now-classic works of the 1980s and 1990s (including Forman, 1990; Hough, 1995; Lyle, 1994; Spirn, 1984; G. Thompson & Steiner, 1997; Thayer, 1994). ARD's emergence also was likely influenced by "eco-revelatory design," which emerged in 1998 with an exhibition, a special issue of *Landscape Journal*, and a lofty goal: to reveal environmental processes at work on sites in the hope of enhancing human recognition of the value of natural systems (Brown & Johnston, 1998). Other research threads relevant to ARD include work in environmental aesthetics by theorists exploring the following: how to make ecological processes

Figure 1
At New Seasons Market, Arbor Lodge, Portland, OR, the rainwater trail tells a story of rain's important impact on rivers and the region's prized salmon. Design: Lango Hansen Landscape Architects PC; Ivan McLean; photograph: Stuart Echols, 2013.

appealing to the American public (esp. Nassauer, 1995, 1997); whether awareness of ecological processes impacts aesthetic appreciation (e.g., Eaton, 1997, 1998; Carlson, 1995, 2001); and whether eco-revelatory strategies could impact environmental behavior (e.g., Gobster et al., 2007; Heeren et al., 2016).

Early examples of green stormwater infrastructure with an aesthetic and/or informative component include extensive sustainable stormwater management systems in Malmö, Sweden, largely spearheaded by Peter Stahre (2005, 2006); designs and publications of Herbert Dreiseitl in Germany (Dreiseitl et al., 2001; Dreiseitl & Grau, 2005); and groundbreaking work in Portland, OR, largely led by the Bureau of Environmental Services environmental specialist Tom Liptan and BES designer Kevin Perry. In the 1990s and early 2000s, under its editor William J. Thompson, the U.S. professional journal *Landscape Architecture Magazine* published numerous staff-written articles on stormwater management that visibly celebrates rain (W. J. Thompson, 1999; Leccese, 1997; Brown, 2001, Rigsby, 2004; W. J. Thompson, 2004; Owens Viani, 2005).

Inspired by the opportunities afforded by this revelatory approach to rain management, the authors began to study ARD examples nationwide in 2005. We coined the term "artful rainwater design," offering clarification of ARD as "design that combines the utility of stormwater management with the amenity of rich placemaking focused on the rainwater itself" (Echols & Pennypacker, 2006, 24). We have made numerous professional and academic presentations nationwide and published in both professional and scholarly venues, with our core ideas presented most robustly in *Landscape Architecture Magazine* (2006, 2008); *Landscape Journal* (2008); and finally, our book (2015). As exemplified in the following quote and image (Figure 1) from our book introduction (Echols & Pennypacker, 2015, 2–3), our position toward ARD is one of advocacy: "By creating sustainable stormwater management systems that visibly communicate their management strategies, we can make people aware of rain as a resource."

Scholarly articles have referenced our ARD concepts, expanding upon them (Ødegård, 2016; Andersen et al., 2017; Darnthamrongkul & Mozingo, 2021) or critiquing them (see esp. Gallo et al., 2012; Sleegers & Brabec, 2014). ARD has been featured as a topic of landscape architecture student studies nationwide (e.g., Sparnicht, 2012; Cesanek, 2013; Huggler, 2019; B. J. Thompson, 2020; Taft, 2023). In other words, it is a strategy that has gained some traction in the landscape architecture community as a multi-benefit, environmentally responsible, experientially rich approach to rain management.

But as exciting as ARD may be, it is far from easy to carry out. ARD must not only *per*form as a rain management system, it must also *in*form. The defining characteristic of ARD is its "rain message," its visible revelation of rain's activity and impact.

If ARD is to become an accepted, revelatory norm in rain management, designers, managers, and owners of ARDs must ensure that they deliver clear *long-term* rain messages. And we have concluded, by repeat visits to ARDs around the United States, that much can be learned by studying ARDs over time. Consequently, we determined that one useful way to see how well ARD is doing as a landscape genre is to return to the 20 case studies presented as noteworthy in our 2015 book now that all of these designs are 10–20 years old. How are their rain messages holding up? The answer is varied and points to important lessons about successes and non-successes that can help future ARD designers.

RESEARCH QUESTION, METHOD, AND LIMITATIONS

This study focuses on the feature of ARD that distinguishes it from other forms of rain management: its revelatory "rain message," or the story presented within the design that shows where rain is coming from (a roof, paved surface, etc.) and where it is going (to water plants, into a cistern for future use, into a stream, etc.). Sometimes the "rain message" presents a broader story of rain's important impact on local ecologies, but in every case, the message is what makes ARD *artful* rainwater design. The research question is therefore: Can we derive useful considerations to guide designers toward long-term "rain message legibility" in future ARDs? (Note that references to rain message legibility, durability, and clarity are used interchangeably throughout this essay.)

Our method was to revisit the case studies, all now 10–20 years old, from our 2015 book. We'd chosen this set of designs as particularly noteworthy examples of ARD that varied in geographical context within the United States. The current study explores these projects in two ways. First, we updated site observations by revisiting the case study designs either personally or through updated imagery from the designers and/or Google Streetview to see what aspects of the rain message legibility had either changed or endured. This resulted in observation-derived themes about the legibility of those rain messages in 17 of the 20 case studies. We then used the basic coding method of qualitative analysis to organize our site observations into a simple set of negatives and positives related to the updated clarity of the rain message, resulting in a set of "observation-derived themes." Second, we interviewed case study designers, managers, and "interested parties" to explore different perspectives. We began with the designers with whom we'd communicated for our 2015 book and asked them to suggest other potential interviewees. We obtained 34 interviews from representatives of 17 case study projects. We coded their responses to a set of semi-structured questions, resulting in a set of "interview-derived themes" parsed simply into positive and negative comments related to rain message legibility. Finally, we collated observation-derived themes and interview-derived themes to find points of intersection focused on the projects' rainwater message legibility. Those intersectional points led to a set of considerations to help ensure the long-term durability of rain messages in ARDs.

The most important limitations of this study are the small number of designs and the fact that updated images and site visits reveal only a moment in time that may not represent an ARD's typical appearance. This limitation is particularly salient for sites visited during the COVID-19 pandemic, when landscape maintenance regimes suffered in many contexts. Other limitations are those typical of qualitative analysis: interviewees' and researchers' inevitable biases and the inherent imperfection of analysis derived through data coding.

THE CASE STUDIES UNDER REVIEW

When we began studying ARD in 2005, we found few examples nationwide; most were in the Pacific Northwest. In our early *Landscape Journal* article, we explained how we chose the projects:

> We developed a list of ARD projects from around the nation by reviewing the past ten years of ASLA and AIA awards for designs whose clear intent included stormwater management systems devised to create site amenities, namely increased attractiveness or value focused on the experience of rainwater. We then asked the project designers, as well as experts in stormwater issues, to recommend other designs representing the best in ARD. We reviewed the most frequently recommended projects and arrived at a list that represents a diversity of setting, project type, and runoff treatment methods. (Echols & Pennypacker, 2008, 270)

Table 1. Case Studies

Design	Location	Designer	Year Built
10th @Hoyt	Portland, OR	Koch Landscape Architecture, Ankrom Moisan Associated Architects	2004–05
ASU Polytechnic Campus	Mesa, AZ	Ten Eyck Landscape Architects, Lake|Flato Architects	2008
The Dell	Charlottesville, VA	Nelson Byrd Woltz Landscape Architects, Biohabitats nc, PHR&A, Nitsch Engineering	2005
Stephen Epler Hall	Portland, OR	Atlas Landscape Architecture, KPFF Consulting Engineers, Mithun	2003
Growing Vine Street	Seattle, WA	Gaynor Inc, Carlson Architects, SvR Design Company, Buster Simpson	2003
High Point	Seattle, WA	SvR Design Company, Mithun, Bruce Meyers, et al.	2000–10
Historic Fourth Ward Park	Atlanta, GA	HDR, Wood + Partners	2009–11
Kansas State ISC Rain Garden	Manhattan, KS	Department of Landscape Architecture/Regional & Community Planning, Kansas State University	2007
Mount Tabor Middle School Rain Garden	Portland, OR	Kevin Perry, Portland Bureau of Environmental Services	2006
NE Siskiyou Street	Portland, OR	Kevin Perry, Portland Bureau of Environmental Services	2003
Oregon Convention Center Rain Garden	Portland, OR	Mayer/Reed	2003
Outwash Basin at the Stata Center	Cambridge, MA	OLIN, Nitsch Engineering	2003
Pacific Cannery Lofts	Oakland, CA	Miller Company Landscape Architects, David Baker Architects	2009
Pierce County Environmental Services	University Place, WA	Bruce Dees & Associates; SvR Design Company. The Miller|Hull Partnership, Arai/Jackson Architects	2002
Queens Botanical Garden	Flushing, NY	Atelier Dreiseitl, Conservation Design Forum, BKSK Archtects	2004
Ridge and Valley Terrace	University Park, PA	Stacy Levy, MTR Landscape Architects, Overland Partners	2009
Shoemaker Green	Philadelphia, PA	Andropogon Associates Ltd., Meliora Design LLC	2012
Southwest Recreation Center	Gainesville, FL	RDG Planning and Design	2010
Swarthmore Science Center	Swarthmore, PA	ML Baird & Co	2004
Washougal Town Center	Washougal, WA	GreenWorks, Sienna Architecture Company, Ivan McLean	2005–07

To determine the case studies that appeared in our 2015 book, we mined that 2008 study set and expanded the list to increase geographic diversity. The result was a set of 13 projects from our 2008 study plus seven more, presented in Table 1.

The current research returned to the 20 case studies from our book for two reasons: First, they were award-winning designs recognized in their early years as noteworthy; second, they are now all 10–20 years old, an age at which many landscape designs exhibit significant changes.

SITE OBSERVATIONS

Method

Because this study focuses on ARD rain message legibility, revisiting the sites was a key step to learn what physical features had changed or remained within the original rain messages. Site observation included physical visits wherever possible, supplemented by updated photographs. In all we obtained new site observations for 17 projects in the following manner:

- We personally revisited 15 projects.
- Designers provided updated imagery for 6 projects.
- We reviewed Google Streetview imagery for 9 projects.

Our analysis compared observations on first site visits (1–3 years post-implementation) with observations on return visits (8–20+ years post-implementation) as well as updated images from the designers and/or Google Streetview. We noted and documented characteristics that had changed or remained the same over time, then parsed our site observations into two simple categories: positives, where the rain message remained strong and clear, and negatives, where change detracted from the rain message. Those results are presented by project in Table 2.

Observation-Derived Themes

Our next step was to categorize related observations into themes focused on rain message legibility. This analysis of site observations resulted in the following set of positive and negative themes related directly to rain message legibility.

Positive observation theme 1: Rain message legibility is consistently retained when the rainwater trail moves through hardscape devices. such as scuppers, aqueducts, curb cuts, level spreaders, structural runnels, and trench drains (Figures 2, 3). Sculptural elements are also durable communicators of the rain message (Figure 4).

Positive observation theme 2: Rain message legibility can be retained by signage. Indeed, sometimes the only form of rain message is signage (Figure 5).

Positive observation theme 3: Rain message legibility can be retained through plant trimming and editing. (Figures 6, 7). This is facilitated by placing plants within containers (Figure 8).

Negative observation theme 1: Dramatic plant change can significantly diminish rain message legibility. (Figures 9, 10).

Negative observation theme 2: Long-term buildup of silt, sediment, or algae may diminish observer enthusiasm for the rain message. (Figures 11, 12). Ironically, while visible silt or sediment in an ARD shows that the system is preventing detritus from moving downstream, if it is allowed to remain for too long, visitors may find the ARD unattractive and the rain message less compelling.

Negative observation theme 3: Water force can move materials in the rainwater trail, significantly diminishing rain message legibility. (Figures 13, 14).

INTERVIEWS

Site observations were complemented by interviews with case study designers, managers, and others to provide additional breadth and depth of perspective and context.

Method

Twenty-seven semi-structured interviews were conducted with 34 participants (20 designers from 17 projects; 6 managers from 4 projects; 8 "interested parties" from 8 projects) in a process approved by our university's Institutional Review Board using the following questions:

- Are you happy overall with its maturation?
- What do you think has worked well in this design?
- What would you do differently?
- Do you know of any monitoring studies conducted on this project?
- Are there others we should contact for more information?

Note that our interview questions were intentionally broad to avoid biasing interviewee responses.

Analysis of the interviews followed the same basic process as analysis of the observations: qualitative

Table 2. Site Observation Matrix

Design	Positive Observations	Negative Observations
10th @Hoyt	• rain message clear in hardscape elements: downspouts, stepped runnels, level spreader, horizontal runnels • rain message remains lively and eye-catching • rain message clarity near plants is retained through plant editing, trimming	• silt deposits in river stone
The Dell	• rainwater trail clear in hardscape elements: raised channel to level spreader to pond; upper pond to forebay to lower pond • rain message clear in signage	
Growing Vine	• rain message clear in hardscape elements: planted downspout; downspout to "Beckoning Cistern"; stepped basins below cistern • "Beckoning Cistern" and planted downspout remain eye-catching	• some algae buildup in concrete scuppers of stepped basins • river stone rainwater trail no longer evident in Pea Patch • plant growth obscures rainwater trail in Pea Patch
High Point	• rain message clear in hardscape elements: "raindrops" incised in sidewalk; downspouts to salmon splash blocks; curb cuts to swales • rain message clear in signage	• plant growth obscures rain message in planted swales • some algae buildup in salmon splash blocks
Historic 4th Ward	• rain message clear in hardscape elements: river rock lines in walls denoting 100-year and 500-year storm levels	• uncontrolled and weedy plant growth in many areas • weeds and sediment in spiral runnel • debris blocks large pipe opening to major runnel • river stones embedded in major runnel largely removed by water flow
Kansas State ISC	• rain message clear in hardscape elements: scuppers from gutter • signage explaining native plants helps to mitigate perception of weediness • flowering of native plants helps to mitigate perception of weediness	• plant growth obscures rain message in rain-receiving bowls and rain garden cells • leggy, uncontrolled plant growth in many areas
NE Siskiyou Street	• rain message clear in hardscape elements: curb cuts into curb extensions • rain message clear in signage	• plant growth obscures rain message in curb extensions • clay and riverstone checkdams replaced with concrete
Oregon Convention Center	• rain message clear in hardscape elements: scuppers from wall; abstracted riverbed; weirs • rain message clear in signage • rain message clarity near plants is retained through plant editing, trimming	• some debris in rainwater trail
Outwash Basin at the Stata Center	• rain message clear in signage	• dramatic plant removal changes appearance
Pierce County Environmental Services	• rain message clear in hardscape elements: scupper from roof; spiraling water channel • rain message clear in signage	• plant growth obscures rain message in many parts of system • weeds and sediment in rock-lined swale • some faded, scratched signage
Queens Botanical Garden	• rainwater trail clear in hardscape elements: fountain to rainwater stream; concrete channel • rain message clear in signage	• weeds in pavers along rainwater stream

(continued)

Table 2. Site Observation Matrix

Design	Positive Observations	Negative Observations
Ridge and Valley Terrace	• rain message clear in hardscape elements: butterfly roof to wall scupper; rainwater drop from scupper to incised rivers and streams in terrace • rain message clear in signage	
Shoemaker Green	• rain message clear in hardscape elements: trench drains to curb cuts into rain garden • rain message clear in "Discover Penn" cell phone audio tour recording	• significant plant change obscures rainwater trail in rain garden • extensive plant growth and loss in rain garden • displacement of river stone in rainwater trail renders trail invisible
Southwest Recreation Center	• rain message clear in hardscape elements: wall scuppers to bowls to runnels to rain garden • sculptures and hardscape rainwater trail reman eye-catching • rain message clear in signage for sculptures	
Stephen Epler Hall	• rain message clear in hardscape elements: downspouts to rain boxes to scuppers to runnels to sunken planters	• debris at water pipe entry into planters
Swarthmore Science Center	• rain message clear in hardscape elements: water wall to raised runnel to stone-filled basin; stepped runnel to raised runnel to stone-filled basin • rain message clear in signage	• some encroachment of plants obscures part of one runnel • some algae buildup in concrete stepped runnel
Washougal Town Center	• rain message clear in hardscape elements: aqueduct to splash sculpture to level spreaders to planter box; downspouts to level spreaders to planter boxes • rain message clarity near plants is retained through plant editing, trimming, some replacement with river stone	

Figures 2 and 3
This Swarthmore College Science Center hardscape rainwater trail retains its rain message legibility (rooftop to water wall to elevated runnel to rock-filled basin) with signage clarifying the rain's storage in a cistern for future use. Design: M. L. Baird and Company; photographs: Stuart Echols, 2013 and 2021.

Figure 4
The sculptural "Beckoning Cistern" provides a durable rain message, reaching its hand to the building downspout to receive rain. A cistern valve opens to send rain into planters downhill. Design: Buster Simpson; photograph: Stuart Echols, 2013.

analysis through coding was used to derive themes on positive and negative comments related to rain message legibility. In this case, data were coded using three iterative steps (open, axial, selective); coding was recorded using NVivo software and resulted in a set of themes that we parsed into positives and negatives. Then, in a fourth phase of coding, we focused on those themes most pertinent to long-term rain message legibility. The coding sequence was as follows:

Open Coding. In this first step of coding, data was simply organized by topic. We identified 19 topics addressed in the interviews, presented in Table 3 and ranked from most to least frequently mentioned.

Axial Coding. In the second pass of coding, topics were consolidated into related categories and subcategories, or parent/child codes. Those topics with no "children" and/or low insight potential were dropped, resulting in the 12 topics shown in Table 4.

Selective Coding 1. Selective coding gathered codes into connected categories. In this study those categories were simply "positive" and "negative," resulting in six positives and six negatives, as shown in Table 5.

Selective Coding Refinement. In the final step we retained only codes that related to rain message

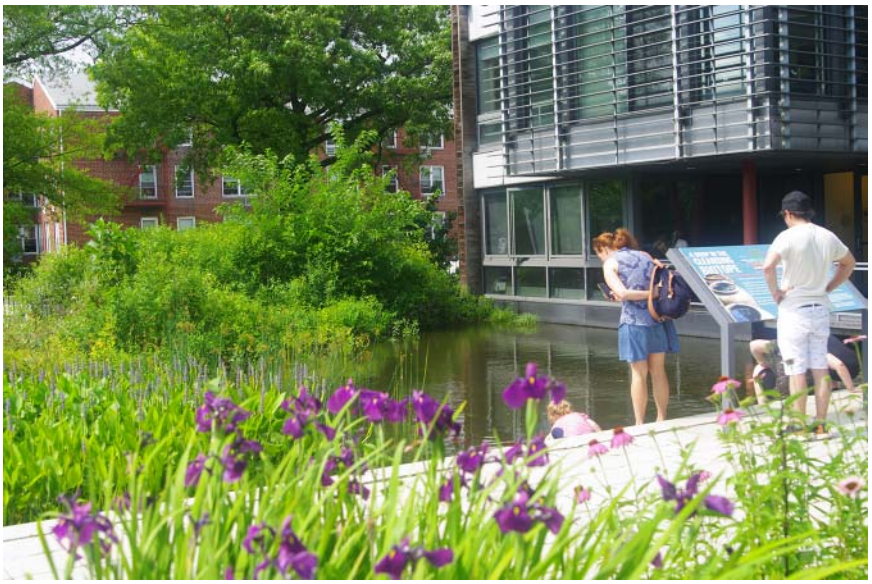

Figure 5
At Queens Botanical Garden a pool of rainwater is cleansed by plants, with a "Cleansing Biotope" message delivered through signage. Design: Atelier Dreiseitl with Conservation Design Forum; photograph: Stuart Echols, 2021.

Figures 6 and 7
Plant editing at the Oregon Convention Center ensures visibility of the rainwater trail. Design: Mayer/Reed Associates; photographs: Stuart Echols, 2005 and 2014.

Figure 8
Vegetation in planters at Washougal Town Center is easily trimmed or substituted to ensure legibility of the downspout-to-level spreader-to-plants rain message. Design: Greenworks (Mike Faha), 2020.

Figures 9 and 10
At Pierce County Environmental Services, plant growth has reduced the legibility of a key rainwater trail. Design: Bruce Dees & Associates, SvR Design Company, The Miller|Hull Partnership; Figure 9 photograph: Stuart Echols, 2006; Figure 10 photograph: Bruce Dees, 2021.

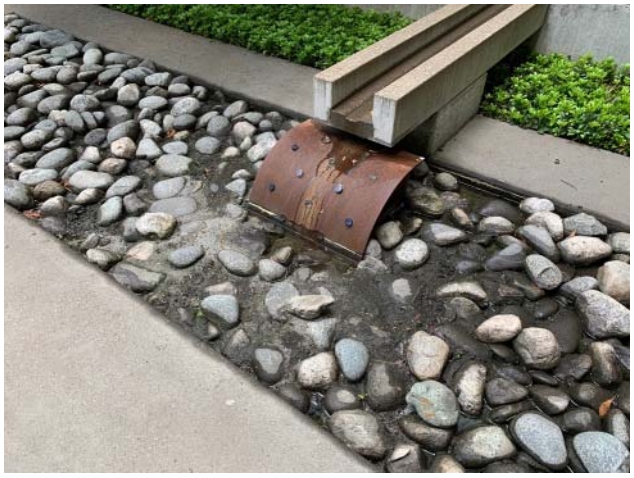

Figure 11
Long-term sediment buildup in a basin at 10th @Hoyt could result in diminished visitor appreciation for the design and its rain message. Design: Koch Landscape Architecture; photograph: Steve Koch, 2021.

legibility, resulting in three positive and four negative comment codes, as shown in Table 6.

Interview-Derived Themes

Within each interview-derived theme there are subthemes and points that address the issue of rain message durability. Each theme is presented here with a very brief discussion, followed by a table that presents its subthemes supported by illustrative quotes.

Positive comment theme 1: Durability of certain physical elements can help retain ARD rain message legibility. Interviewees identified some key design characteristics in this category. Twelve interviewees shared 15 thoughts on this topic, with subthemes and illustrative quotes found in Table 7.

Figure 12 A pipe outlet carrying rainwater at Historic Fourth Ward Park is blocked by debris, potentially diminishing visitor appreciation for the rain message. Design: HDR; photograph: Eliza Pennypacker, 2021.

. . .

The remaining positive comment themes address not so much physical features as the benefits derived from an ARD approach to rain management. This is not surprising, given our open-ended interview questions; and these positive comments corroborate many of the benefits of ARD for which we have advocated in our work to date.

Positive comment theme 2: A clear rain message can enhance public awareness and understanding of rain. This was a popular topic among our interviewees, with 32 comments from 17 interviewees. Illustrative quotes are found in Table 8.

Positive comment theme 3: An ARD approach can transform rain management into a multi-benefit solution. Only eight comments on this topic were offered by six interviewees—but those remarks were compelling. Subthemes and illustrative quotes are found in Table 9.

Negative comment theme 1: Deterioration of physical elements can diminish rain message legibility. Interviewees identified two categories of

Figures 13 and 14
At Shoemaker Green, a lilting rainwater trail defined by river stones has been completely displaced, likely by moving water. Design: Andropogon Associates Ltd; photographs: Stuart Echols, 2013 and 2021.

Table 3. Open Coding

	# people	# comments	
Plants	27	143	
Utility	29	132	
Maintenance	30	130	
Amenity	29	96	
Monitoring	31	93	(interview question; high response expected)
Durability	29	92	
Satisfaction	30	116	(interview question; high response expected)
Understanding	23	103	
Information sharing	22	72	
Lesson learned	11	41	
GSI evolution	13	30	
Collaboration	15	27	
Deterioration	7	27	
Safety	8	16	
Wildlife	5	9	
Staff turnover	4	7	
Multiple benefits	5	5	
Return on investment	1	5	

deterioration that can negatively impact rain message legibility: the erosive force of water movement and signage degradation. Another form of physical degradation—plant change—was such a big topic that it will be addressed below in its own theme. Nine interviewees made 13 comments on this topic. Subthemes and illustrative quotes are found in Table 10.

Negative comment theme 2: Plant change can diminish rain message legibility. Everyone who works with plants over time recognizes that they are living, changing organisms: some grow, some wither; some are aggressive, some well-behaved. And, as both our interviews and updated site images attest, unexpected plant change can hide a thoughtfully designed rainwater trail, obscuring an ARD's revelatory power. Plant change can also change the design character dramatically (e.g., where leggy or weedy plant growth or plant loss has occurred), potentially diminishing visitor appreciation for the design. Nineteen interviewees shared 34 thoughts on these issues. Subthemes and illustrative quotes are found in Table 11.

. . .

Maintenance is a huge issue, key to the long-term success of any landscape design; but ARDs are particularly unforgiving of poor maintenance. In addition to the challenge of maintaining the functionality of the rain management system, maintenance of ARDs must retain legibility of the rain message. This was such a popular and multifaceted topic among our interviewees that we

Table 4. Axial Coding

"Parent" Codes	"Child" Codes
Plants	plants added plant success good plant success problem invasives and weeds plants removed or replaced plant decline
Maintenance	amenity maintenance silt and sedimentation utility maintenance ways to improve maintenance
Monitoring	formal study informal observation no monitoring
Durability	rain message system function
Satisfaction	owner/manager designer interested party public
Understanding	staff public
GSI evolution	early experimentation innovation precedent-setting
Collaboration	project complexity interdisciplinary professional respect
Deterioration	rain message system function
Safety	slope of swale unnecessary safety feature visibility hazard of plants water as attractive nuisance
Wildlife	charismatic wildlife undesirable wildlife
Multiple benefits	educate combine SWM with landscape add value

broke maintenance issues down into two topics in this study.

Negative comment theme 3: Lack of maintenance capacity, consistency, and clear responsibility can devastate an ARD (and its rain message legibility). Eighteen comments by 12 interviewees focused on the importance of conducting maintenance in ARDs. Subthemes on the importance of maintenance and illustrative quotes are found in Table 12.

Table 5. Selective Coding 1

Positive Comment 1	Durability of physical elements
Positive Comment 2	Enhanced public awareness, understanding
Positive Comment 3	ARDs can provide multiple benefits
Positive Comment 4	Early experimentation/innovation
Positive Comment 5	GSI evolution
Positive Comment 6	Wildlife (charismatic)
Negative Comment 1	Deterioration of physical elements
Negative Comment 2	Plant change problems
Negative Comment 3	Maintenance capacity, consistency, clear responsibility
Negative Comment 4	Maintenance staff understanding
Negative Comment 5	Monitoring
Negative Comment 6	Wildlife (undesirable)

Table 6. Selective Coding Refinement Focused on Rain Message Legibility

Positive Comment 1	Durability of physical elements
Positive Comment 2	Enhanced public awareness, understanding
Positive Comment 3	ARDs can provide multiple benefits
Negative Comment 1	Deterioration of physical elements
Negative Comment 2	Plant change problems
Negative Comment 3	Maintenance capacity, consistency, clear responsibility
Negative Comment 4	Maintenance staff understanding

Negative comment theme 4: Lack of maintenance staff understanding can undermine long-term ran message legibility (and ARD functionality). While the last theme focused on the importance of "doing" maintenance, this theme focuses of the importance of staff understanding of what needs to be done. ARDs

Table 7. Durability of Physical Elements: Subthemes and Illustrative Quotes

An interesting ARD design commands attention	There's enough interest in what's going on with the water and these runnels and the lighting at night. . . . And the sound of water is part of that. So that's critical: the auditory sound of water.
Sculptural elements in an ARD can be durable, eye-catching contributors to the rain message	Typically in those art and state programs somebody designs a mural and they stick it inside the building, and only the people who go into the building see it. Early on our design team advocated for bringing whatever that art was outside. . . . That [sculptural] element I think is enough to get people interested so they may stop and say "what is this about?"
Hardscape rain message elements can require little maintenance	I think that really making the stormwater visible has been a really nice thing, a real advantage to this project. Actually those visible [hardscape elements] require very little maintenance at all.

Table 8. Enhanced Public Awareness and Understanding: Subthemes and Illustrative Quotes

The rain message can enhance visitors' awareness of rain	I think it's important to have that intense visualization of what's going on, because people don't know what's happening to rain. And to become more responsible for it, you need to know that progression that it takes from sky to ocean, and where we fit into that.
	In many ways it makes stormwater visible to visitors, to students, to faculty, to staff in that they can see it—from the rainwater pouring off the roof or going down the water stairs and then having our signage explain what's happening there.
The rain message may influence people's actions	The great part about that is that people who are coming to get their permits would have to go through this living laboratory and [ideally would say,] "Hey, this would look great at my place."
The rain message can be used as a teaching tool	Usually I have a class activity out there every spring and then I show it in various classes, and I talk about it in different ways. When I'm talking about green infrastructure with the public, I always show that garden.
ARD signage can help convey the rain message	Even if you're just walking by, there's enough signage out there that if you just have your eyes open, you can say, "Oh what's this placard telling me?" And all of a sudden you've learned something . . .

Table 9. ARD Approach as a Multi-Benefit Solution: Subthemes and Illustrative Quotes

An ARD can become a community asset	Almost all the properties in the neighborhood that face onto [this ARD] have cut a gate in their fence, so that they have easy, direct access to walk in the [site]. So that is a sign that it has been appropriated, you know, by the neighboring property owners.
ARD at schools can teach the next generation	Students [at this university] are learning, and if they can learn by observing, they're going to take that into whatever they do.
	It's helped us realize, beyond the confines of Portland, that schools are an important aspect of what we could do with stormwater management and do it in an artful way.
ARD can provide added value	When you can accomplish three or four things with the same amount of money it would [take] to do one thing, you're adding value for your clients. So in this case, we needed to provide circulation, an entrance, we had to handle stormwater. And art was included. We basically said, all those are one thing. It cost more than a traditional stormwater solution, but when you add that value into all of it, all those program elements, it was the right financial and ecological solution for the [client].

Table 10. Rain Message Legibility Deterioration: Subthemes and Illustrative Quotes

Water movement force can degrade the rain message	Where we have the [decorative] river stones that are embedded, they just they haven't held up. A lot of them have washed out, and for good reason. We have a lot of water flow through those channels, and it just doesn't look like a stream bed like it was intended.
	When we originally designed the project we had some clay checkdams installed to help slow the water down as its moving through the system, and then that was reinforced with some larger rock and cobble that, [in] larger storm events, started to erode. It wasn't very long after that project that I started moving towards more structural, elegant, different ideas of how we can slow the water down; but with something that is more structurally strong.
Signage deterioration can reduce rain message clarity	In some instances, where's a lot of canopy cover, there's vegetation growing on some of the signs, if you will. And so they could do a little better job of keeping those clean and visible.
	The signage had deteriorated and was difficult to read.

Table 11. Plant Change: Subthemes and Illustrative Quotes

Plant growth can obscure the rain message	It's quite difficult to see the water movement. . . . [because] the plant material is growing so well.
	Coming off our roof are these gutters, and the water in the gutter runs into these tubes and then is directed down into these containers. [The containers] are decorative and they're pretty. But you can't see them anymore because there's stuff growing over them.
	To me, the only things that haven't worked well are the plantings. And it's just because they've grown too big for their space.
Lack of knowledge of local plants can result in poor choices	Okay, so full disclosure: I'm not from X, I'm a landscape architect who was doing a project in X. And I knew some of the plants there, but we selected some plants that were overly aggressive, so the plant ecosystem of this changed rather quickly. In just a few years, some things took over.

Table 12. Management Capacity, Consistency, and Clear Responsibility: Subthemes and Illustrative Quotes

A design must be calibrated to maintenance capacity	when you do any project in the public realm, find out what the level of maintenance capability is, and that has to be part of your design.
	"How will they be maintained?" is a question they always ask. We ask that question of our clients as well. If it can't be well-maintained, we can't put it at the front door.
Maintenance must be consistent for long-term success	So much of a site's success is dependent upon the maintenance that's done over the time after the shine has worn off, so to speak. And if it's not maintained and kept in good functioning condition, it can deteriorate just due to time.
	It just needs to be routine maintenance. It would be less of a job if they did it more often, right? If they clean this out once and for all and started fresh.
Maintenance responsibilities must be clear for long-term success	Now, in terms of what doesn't work it's more on the management side: There really needed to be a better agreement between watershed management and parks as to the management of this.

differ from traditional landscapes where staff mow, mulch, edge, and weed. Maintenance staff may be unfamiliar with the rain management system and/or the plants and their requirements. ARD designers hope that staff will understand or learn about the plants and systems, but this is a true challenge that can lead to diminished rain message legibility and ARD aesthetic quality. The problem is exacerbated by staff turnover and lack of knowledge transfer. Nine interviewees offered 23 comments on this topic. Subcategories and illustrative quotes are found in Table 13.

Table 13. Maintenance Staff Understanding: Subthemes and Illustrative Quotes

Maintenance staff who don't understand the ARD intent and system will neglect it at best and thwart it at worst	[It's essential to have] the facilities folks, the ones responsible for managing the site, at the table during the design process and making sure that they all understand what the design goal is here and how the operations really [work].
	So, none of that is working right now, mostly because people don't understand the system. . . . But they keep on piling up rock so it doesn't overflow, not understanding that it's overflowing because it's clogged up.
Traditional grounds maintenance crews are unfamiliar with—and often reluctant to address—native plants typical of ARDs	You know, it's just that our grounds crews are not trained horticulturists, so the complexity of the planting in this kind of naturalistic setting is just hard for them to identify. . . . They're scared when they see all these plants together, they're scared to remove something for fear it's an intentional, desired plant. And so they are leaving things that become out of control and invasive.
Lack of knowledge transfer about an ARD facility can lead to major problems	We worked with the then-Director of design for the Parks Department; and I'm not absolutely certain he communicated to anyone in Facilities what all was being designed and built.
	And because of the turnover in the maintenance world, we can train the crew that's working there today, and tomorrow it can switch out, and suddenly things go to wreck and ruin because the trained people have moved on to other jobs and there's a new crew that didn't get the training.
Maintenance manuals are essential to help staff understand ARDs; but they must be user-friendly	The maintenance manual that we got from [the designer] is 1000 pages long, and nobody's actually read all of it. I have flipped through relevant parts of it, but some of it isn't really relevant—just documents they have to give you.

CONCLUSION: A SET OF USEFUL CONSIDERATIONS FOR FUTURE ARDS

The answer to our research question is yes: by returning to the case study sites using a combination of observation-based and interview-based analysis, we have been able to derive a set of useful thoughts for maintaining an ARD's rain message legibility. We gleaned the following important considerations from the intersection of site observation-derived themes and interview-derived themes found through this study.

Consideration 1: A "Lively" Design. (from Positive Observation Theme 1 and Positive Comment Theme 1)
According to some of our interviewees and observations, a design that is lively and engaging, presenting a variety of water movement and even water sounds, may enhance the durability of the rain message. Such a design captures people's attention—and that attention may make owners/managers loathe to risk losing that benefit through poor maintenance.

Consideration 2: Hardscape and Sculptural Elements. (from Positive Observation Theme 1 and Positive Comment Theme 1)
We observed that hardscape conveyance devices (scuppers, runnels, level spreaders, etc.) retain rain message legibility better than rainwater trails created by plants and/or river stone. Some of our interviewees additionally declared that visible hardscape elements in ARDs can require very little maintenance. Sculptural elements addressing rain message legibility also can have great durability in terms of both material and rain message.

Consideration 3: Signage. (from Positive Observation Theme 2 and Positive Comment Theme 2)
Long-term rain message legibility can be significantly enhanced by signage that communicates facets of the ARD not immediately apparent to visitors. A caveat voiced by some interviewees is that signage must be well-maintained for long-term clarity of the rain message.

Consideration 4: Water Movement Force. (from Negative Observation Theme 3 and Negative Comment Theme 1)
In an ARD rainwater trail, water can move with considerable volume and force—in turn moving or eroding materials in its path. In the case studies we

observed this impact on plants, clay check-dams, and river stone—even river stone embedded in concrete. This challenge relates to Consideration 2 (see above): rainwater trail conveyance that is a simple hardscape runnel may have longer-term rain message legibility.

Consideration 5: Plant Change. (from Negative Observation Theme 1 and Negative Comment Theme 2)
Changes in plants are a challenge in any landscape design; but here we focus on those changes that impact the ARD rain message legibility. Plant growth can hide elements of the rain message; "leggy" growth, "weeds," plant loss or withering may diminish visitor enthusiasm for the design and/or the rain message. But plant change does not inevitably diminish ARD impacts if plants are chosen and spaced with careful consideration of their mature size. Plants should be trimmed regularly and edited periodically.

Consideration 6: Maintenance. (from Positive Observation Theme 3, Negative Observation Theme 1, Negative Comment Themes 3, 4)
This consideration may be the single most important one for ARDs as it is key to the durability or deterioration of rain message legibility (as well as to every other ARD facet).

Multiple interviewees spoke of the importance of design that acknowledges maintenance capacity—in terms of manpower, clear designation of maintenance responsibilities, and the maintenance staff's understanding of how the ARD works and is expected to look. We also heard repeatedly about the importance of ensuring staff understanding of necessary maintenance activities and their frequency. Additionally, we heard about the challenge of maintenance knowledge transfer in the context of frequent turnover of site stewards, whether volunteer or paid. All of this suggests that long-term success of the rain message legibility (as well as rain management function) might be dramatically enhanced by a user-friendly Maintenance and Operations Plan (MOP). To truly be useful, a MOP should fit into the pockets of maintenance staff onsite, whether as a smartphone App or as a laminated document, so that helpful information is always at hand. Such a MOP may also ameliorate the knowledge transfer challenge, making essential information as accessible to new stewards as it was to those who preceded them.

These interview comments were corroborated by our site visits. Lack of maintenance in ARDs—as in all landscapes—instantly communicates lack of care; and deterioration of rain message legibility due to poor maintenance may suggest a loss of owner/manager interest in this defining ARD feature. It should be noted, though, that we saw in our site visits and heard from multiple interviewees that strong maintenance can have a major positive impact: an ARD that presents a well-maintained landscape can become a local asset, beloved by its constituency. This kind of positive user relationship with an ARD site can in turn enhance its long-term care and durability.

FINAL THOUGHTS

ARD is an approach to rain management with considerable appeal for landscape architects for an array of reasons: it expands opportunities for landscape architects to address a site challenge historically controlled by engineers; it provides a rationale to keep a landscape from being "value engineered" out of a development plan; it demonstrates a viable means to let soil and plants manage rain onsite; it provides function, beauty, and information all in one design; and it has the potential to change people's perceptions of rain so that they begin to view it as a resource rather than a waste product. What's not to love, as the authors' decades of presentations and publications to date have declared?

But study of ARDs over time reveals that the challenges of long-term success for ARDs are many. Do the challenges outweigh the potential benefits? The answer depends on realistic considerations—including those presented here—that must be weighed in the context of each design project.

In sum: It is important that designers and owners be clear-eyed when considering implementation of an Artful Rainwater Design. The potential benefits are considerable, but recognition of the challenges is essential. Ideally, studies like this one provide the kind of useful information needed for future ARD success.

As stated at the outset, this study focuses on the defining feature of ARD: the rain message and its long-term legibility. The study is limited in scope by the number of data sets (17 revisited projects and 34 interview respondents) and by the need to focus on a single topic within ARD for the purpose of

addressing an important research question. Method limitations were articulated earlier. Useful topics for future research include:

- How effectively do ARDs actually impact people's perceptions of rain as a resource?
- Can "best practices" be developed for ARD signage placement and/or design?
- What effective strategies can be developed for plant choice, editing, and replacement in ARDs?
- How effective are ARDs in managing rain?
- Does the rain management function of ARDs change over time?
- What strategies/characteristics make an ARD successful according to cost-benefit analysis?
- What policies can be developed to promote implementation of rain management through ARD?

The current study addresses only the importance of long-term maintenance of *the rain message legibility* in ARDs, leaving the study of many other facets of ARD to future research. But the site observations and interviews presented here reveal an important set of considerations that the authors hope may prove useful to future designers of ARDs.

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