GAME DESIGN DOCUMENT

Super Sundae Scatter

A 5×5, 20-line slot with a centered growing-wild free-spins engine — tuned to a validated 96.5% RTP across multi-million-spin Monte-Carlo runs of the real game logic.

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5×5 · 20 LINES | FREE-SPINS ENGINE | GROWING WILD | HIGH VOLATILITY

96.5%	5,000×	1 in 224	19.6%
VALIDATED RTP	MAX WIN CAP	BONUS TRIGGER	HIT FREQUENCY

All figures in this document are sourced directly from the project's production code, simulator, and Monte-Carlo validation harness — not estimated. Validation: 1,000,000-spin and 5,000,000-spin base runs with full bonus play-out, plus a dedicated 2,000,000-round direct-bonus calibration phase, across multiple seeds. A "Verify Before Publishing" appendix flags the small number of items requiring author confirmation prior to going live.

1 Overview

Super Sundae Scatter is a candy-and-ice-cream-themed video slot played on a 5×5 grid across 20 fixed paylines, with wins paying left-to-right from the leftmost reel at a minimum of three of a kind. The base game is intentionally lean — a high-volatility grind whose purpose is to deliver the player into the bonus, where roughly three-quarters of the game's return lives.

The signature feature is a **single growing wild** in free spins. The wild begins as a 1×1 block at the grid's center and expands one stage at a time — 2×2, 3×3, 4×4, up to a board-filling 5×5 — each time the player collects a third scatter. A geometric placement rule means scatters can only land on cells the wild does *not* already cover, so collection naturally slows as the wild grows, making the full 5×5 a rare, earned climax rather than an inevitability.

ATTRIBUTE	DETAIL
Theme	Candy / ice-cream parlour
Grid	5 reels × 5 rows
Mechanic	Fixed paylines (20), left-to-right, min 3-of-a-kind
Bet range	$0.20 – $20.00 (step $0.20)
Max win	5,000× bet (hard cap)
Headline feature	Free spins with a centered growing wild (1×1 → 5×5)

2 Key Stats

96.5%	20.7%	75.8%	5,000×
VALIDATED RTP	BASE RTP	BONUS RTP	MAX WIN

METRIC	VALUE	SOURCE / METHOD
Overall RTP	96.5% target · 96.51% measured	Monte-Carlo, real game logic
Base-game RTP	20.74%	Validation harness
Bonus RTP	75.78%	Validation harness
Hit frequency	19.60%	Validation harness
Bonus trigger rate	1 in 224.2 spins	Validation harness
Avg. bonus payout	169.90× bet	Direct-bonus simulation
Volatility	High (see verify)	Design intent; no formal class in code
Grid / lines	5×5 · 20 paylines	Config
Validation scale	Up to 5M base + 2M direct-bonus rounds	Multi-seed

How RTP was validated. The headline number is not a model estimate — it is the measured output of running the *actual* game's outcome engine across millions of spins. Base RTP, bonus RTP, hit frequency and trigger rate were all read from the same harness, and a separate two-phase run (5M base spins, then 2M bonus rounds sampled directly) was used to nail the high-variance bonus mean.

3 Core Mechanics

Base spin & win evaluation

Each reel is populated from a weighted symbol pool, then the board is evaluated against 20 fixed paylines. A line pays when three or more matching symbols appear on consecutive reels starting from reel 1; only the highest win per line counts. Adjacency on the grid is irrelevant — this is a payline game, not a cluster game — so a symbol only contributes to a win if it sits on a defined line beginning at the leftmost reel.

- Wilds substitute for all paying symbols and extend a matching run.
- An all-wild line pays as the top symbol.
- The scatter (scooper) never pays on a line; it exists to trigger and feed the bonus.
- On any base spin there is a **4% chance** a single random wild is injected onto the board.

> **Single-evaluation payline slot.** Despite the candy styling, wins are paid once per spin against the 20 lines — there is no cascade/tumble step. This was a deliberate scope decision after an earlier signature mechanic was cut (see §5).

Paytable — full pay values (× bet)

Pays are attached to symbol tiers; values shown are the validated production paytable. Player-facing names for the top three symbols differ from internal IDs (see verify).

SYMBOL		3 OAK	4 OAK	5 OAK
HIGH TIER				
Orange Sherbet	HIGH	1.56	4.68	14.93
Neopolitan	HIGH	1.56	4.68	14.93
Rainbow Sherbet	HIGH	1.11	2.90	7.35
Birthday Cake	HIGH	1.11	2.90	7.35
MID TIER				
Strawberry	MID	0.67	1.56	3.79
Mint	MID	0.67	1.56	3.79
Vanilla	MID	0.45	1.11	2.23
Chocolate	MID	0.45	1.11	2.23
PREMIUM (ICONS)				
Sundae (Seven)	ICON	0.14	0.70	3.53
Banana Split (Bell)	ICON	0.08	0.30	1.23
Milkshake (Star)	ICON	0.05	0.15	0.53

Note: the "icon" symbols carry the game's classic-slot art (7 / bell / star) but the lowest line pays — they are visual variety, not high-tier pays. The scatter and bowl do not pay on lines.

Base reel weights

Per-reel weighting. Within a reel the four low symbols share the "low" weight, the four mid symbols share "mid", the three high symbols share "high". Reels tighten left-to-right.

REEL	LOW (×4)	MID (×4)	HIGH (×3)	SCATTER

4 Bonus Features

Free Spins — the growing wild engine

The bonus triggers on **3 or more scatters across 3 or more reels** (~1 in 224 base spins) and awards **6 free spins**. A single wild sits at the center of the grid as a 1×1 block. Players collect scatters during free spins; **every 3rd scatter grows the wild one stage** and awards **1–2 extra spins**. The wild never shrinks, and the round is capped at **30 total spins** and **5,000× max win**.

6	3	4	30
BASE FREE SPINS	SCATTERS / GROW	GROW STAGES	SPIN CAP

The geometric placement rule

This is the mechanic that gives the bonus its shape. Scatters can only land on cells the wild is *not* covering. As the wild grows from its center, the count of available (uncovered) cells falls sharply, so each successive grow becomes harder to reach. Collection decelerates exactly as the reward escalates.

WILD SIZE	COVERED CELLS	AVAILABLE CELLS	COLLECTION FEEL
1×1	1	24	Fast — easy to feed
2×2	4	21	Brisk
3×3	9	16	Slowing
4×4	16	9	Hard
5×5	25	0	Climax — board filled

> **Head-start banking.** The trigger generosity carries into the bonus: a 3-reel trigger banks 0 scatters, a 4-reel trigger banks 1, and a 5-reel trigger banks 2 — so a bigger trigger gives the player a running start toward the first grow.

Bonus tuning constants

CONSTANT	VALUE
Bonus scatter weight (per reel)	4.5 — elevated & decoupled from the base 1.6, so collection works inside the round
Extra spins per grow	1–2
Wild block geometry	Centered at col 2 / row 2; halfLo = ⌊(N−1)/2⌋, halfHi = ⌊N/2⌋
Bonus share of total RTP	75.78% of 96.5%

Buy Free Spins

Players may purchase the bonus directly for **100× bet**, awarding the identical bonus a natural trigger gives. The buy-price rationale recorded in code is stale and the price's RTP alignment needs confirmation — see verify.

5 Math & RTP Design

The engineering story behind the 96.5% — the levers, the validation method, and the measurement problem that nearly produced a wrong number.

Philosophy

The RTP budget is deliberately lopsided: a lean ~20.7% base game and a dominant ~75.8% bonus. The base game is a high-volatility grind whose job is anticipation, not payout; the emotional and monetary return is concentrated in the free-spins round. This is a Juicy-Fruits-style distribution — the player tolerates a dry base because the bonus is where the game pays.

Validation — real logic, not a model

RTP was validated by running the **actual production outcome engine** through a Monte-Carlo harness, not by an abstract spreadsheet model. The game's math lives in one place (a server-authoritative engine) and the harness drives that same code, so what was measured is what ships.

- **1,000,000** base spins with full bonus play-out (primary seed).
- Multi-seed sweep across seeds 42 / 101 / 777 / 9999.
- Authoritative two-phase run: **5,000,000** base spins, then **2,000,000** bonus rounds sampled directly.
- A 10-seed Python cross-check (5M base + 500k direct bonus per seed) to confirm seed-stability.

The measurement problem that mattered most

The most important lesson in the project was a *measurement* bug, not a logic bug. Early calibration measured the bonus by counting only the bonuses that triggered incidentally through base spins. At 1-in-224, a million base spins yields only ~4,460 bonus samples — far too few to pin a high-variance bonus (σ ≈ 400× bet). The result was an under-powered, misleading RTP reading.

> **The fix:** calibrate the bonus by simulating **hundreds of thousands to millions of bonus rounds directly**, rather than waiting for them to occur through base play. Direct sampling collapsed the standard error and revealed the true mean, after which a single paytable scale correction brought the measured RTP onto target.

```
# Paytable calibration — single global scale onto the v12 target
_V12_SCALE = (96.51 / 97.71) × (96.5 / 97.3629) ≈ 0.97902
# applied uniformly to every pay value → math-neutral re-balance
```

Because the scale is applied uniformly, symbol-to-symbol balance is preserved; only the overall return shifts. The same paytable constant is shared by the simulator and the game engine, so the two cannot drift apart.

Tuning levers, in order of leverage

- **Bonus scatter weight (4.5).** The single biggest lever on bonus RTP — it governs how fast the wild grows, and growth rate drives average bonus payout.
- **Paytable scale (v12).** The global correction that sets overall return without disturbing symbol balance.
- **Base reel weights.** Shape the lean base RTP and the natural trigger rate.
- **Geometric available-cell curve.** Caps how often the wild reaches 5×5, bounding the top of the bonus distribution.

A target that proved impossible — and the call made

Chasing an exact third-decimal RTP on a single seed is the wrong goal for a high-variance bonus: individual seeds legitimately scatter around the mean (e.g. 96.62% vs 96.50%). The correct target is the **mean across seeds** landing on

6 Design Intent

What the player should feel, and why the math is shaped to produce it.

The base game is built to create **longing**. It's dry by design (~20.7% RTP), with a ~19.6% hit frequency that keeps small wins trickling in often enough to sustain a session, but never enough to satisfy — the real prize is always the bonus, dangling at 1-in-224. This is honest tension: the player isn't tricked into thinking a big base win is coming; they're playing toward the feature.

The bonus is engineered as a **climbing arc**. The growing wild gives the round a visible goal — every third scatter is measurable progress, and the geometric slowdown means each successive grow feels harder-won than the last. Reaching 5×5 is rare and earned, which makes it land as a genuine peak rather than a routine event. The 1–2 extra spins per grow create a tug-of-war between the dwindling spin count and the next milestone.

- **Volatility feel:** high — long dry stretches punctuated by bonus-driven spikes.
- **Pacing:** base game as anticipation; bonus as payoff and crescendo.
- **Distinctiveness:** the centered, geometrically-throttled growing wild gives the free-spins round a self-pacing difficulty curve without any artificial gating.

> **Honest-levers principle.** RTP is controlled only through invisible math levers — pay values, symbol weights, trigger rate. Player-facing feedback (win celebration, scatter emphasis) is always tied to a real event, and the game never disguises a loss as a win or manufactures a near-miss.

7 Tech

LAYER	DETAIL
Language	TypeScript 5.4 (strict)
Rendering	PixiJS v8
Animation	GSAP 3.12
Build	Vite 5
Simulator	Python Monte-Carlo harness (multi-seed)

Architecture decisions

- **Server-authoritative outcomes.** All board generation, win evaluation and bonus logic live in a single outcome engine that implements a server-client interface — the client only renders what the engine returns. This mirrors a real certified-RNG deployment, where the client must never decide outcomes.
- **Single source of truth for math.** The paytable, paylines and bonus constants are exported from one module and imported everywhere — the UI, the info screen and the simulator all read the same numbers, so they cannot diverge.
- **Data-driven info screen.** The in-game paytable/rules screen renders pay values live from the exported constants — it is structurally incapable of showing a number the game doesn't actually pay.

> **Why this matters for a math role.** The validation method (real logic, not a model), the single-source-of-truth constant module, and the direct-bonus calibration are the parts of this project that demonstrate production-grade math discipline — the same practices a certified studio applies to keep a game's stated RTP honest.

⚑ Verify Before Publishing

Items the author should confirm against source before this document goes live. None affect the headline RTP, but each is a real discrepancy or gap found during the audit.

BUY FREE SPINS — PRICE RATIONALE

Buy cost is 100× bet, but the recorded rationale is stale. A code comment derives the price from an "avg bonus payout ≈ 109×," but the validated average bonus win is **169.90×**. At a 169.90× mean, an RTP-matched buy would price near 176× (169.90 ÷ 0.965), so the 100× cost makes the buy substantially player-favorable rather than RTP-neutral. Confirm whether 100× is an intentional design choice and state the buy's true RTP, or re-derive the price. Do not publish the buy as "RTP-matched" until resolved.

ANTE / BET HIGHER — NOT WIRED

The ante feature is a placeholder, not a functioning mechanic. Constants exist (ANTE_MULTIPLIER 1.25, ANTE_TRIGGER_BOOST 2) but the trigger boost is never read anywhere in the engine — the bonus trigger uses the standard ≥3 rule with no ante effect. Either omit ante from the published GDD or label it explicitly as planned/un-tuned. (Note: an earlier session stated the ante was "baked into the RTP" — the audit contradicts this; treat it as un-wired until a dedicated ante sim pass confirms otherwise.)

VOLATILITY CLASS

No formal volatility/variance class is recorded in code. "High" is used in this document as design intent only. If you want a stated volatility index/class, compute it from the win distribution before publishing, or keep the qualitative "high volatility" framing.

SYMBOL DISPLAY NAMES

The top three symbols are relabeled in the UI. Internal IDs are sundae / banana_split / milkshake, but the player sees Seven / Bell / Star (art was swapped, IDs kept to protect the math). This document lists both. Confirm which names you want shown publicly and keep them consistent.

DEFAULT BET CONFLICT

Two different default-bet values exist. The live game defaults to $0.20; a config value (GAME_CONFIG.defaultBet) reads $1.00 and is unused. This document uses $0.20 (the live value). Reconcile or remove the unused constant.

MINOR: STALE LABELS & SCALE COMMENT

Two cosmetic code inconsistencies, values are correct. (1) A comment reads "v12 = v11 × 0.97897" while the authoritative scale is ≈0.97902. (2) Harness comparison targets are labeled "v11 targets" but hold the correct post-v12 numbers. Neither affects results; tidy if desired.

PER-SEED RTP FIGURES

Per-seed RTP results are printed at runtime, not stored. The 96.62% / 96.50% seed figures cited come from prior session output, not a persisted constant. If you want exact per-seed numbers in the published doc, re-run and capture them.